DOCUMENT RESUME

ED 038 298 SE 008 229

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TITLE Self Paced Instruction -- A Preliminary Report.
INSTITUTION Texas Univ., Austin. Research and Development Center for Teacher Education.; Texas Univ., Austin. Science Education Center.
PUB DATE [70]
NOTE 139p.

EDRS PRICE EDRS Price MF-$0.75 HC-$7.05
DESCRIPTORS *Autoinstructional Aids, *Elementary School Science, Individualized Instruction, *Instruction, Teacher Education, *Teaching Guides

ABSTRACT

This paper reports on an instructional program based on the assumption that behavioral change on the part of the student will be most effective when it is both intentional and insightful. Changes on the part of the students which are clearly specified before instruction and which are the explicit objectives of the instruction are described as intentional. Insightful refers to the student's acceptance of responsibility in self-directing or pacing of the learning task which implies that the student accepts the learning tasks and has the responsibility for pacing his own activities within that learning task. In designing a self-paced teacher education program, the designers found the following four steps to be essential: (1) Instructional materials had to be systematically designed with explicit behavioral goals and a specific relationship between each of the objectives and the instructional activities; (2) The objectives for the first set of instructional modules were listed on separate cards and sequenced in what appears to be a logical hierarchy; (3) A self-diagnostic test was essential so that each student could identify those tasks that he could do on entering the program; (4) Knowing what he could already do was important to the student because it revealed what he could not do. (BR)

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SELF PACED INSTRUCTION -- A PRELIMINARY REPORT

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and
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for Teacher Education

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Instruction in the college classroom is intended to provide enocunters with those experiences that will enable the student to acquire knowledges and skills essential for success in later life. In the long term view, it is anticipated by the college instructor that successful behavioral change by the student in the college classroom will result in the student being able to be successful in coping with his environment and life tasks after he has left the college campus. But does this occur? Under what circumstances can the college learning experiances be made most functional for the later life of the student?

It is the assumption of this paper that behavioral change on the part of the student will be most effective when it is both intentional and insightful Intentional is here used to describe changes on the part of the students which are clearly specified before instruction, and which are the explicit objectives of that instruction. Insightful as used here, refers to the student's acceptance of responsibility in self-direction or pacing of the learning task which implies that the student know and accepts the goals for the learning task and has the responsibility for pacing his own activities within that learning task. Much research evidence could be cited here, Flanders, for example, that suggest that the way the instructor engineers the encounter is a significant contributor to the outcome of the encounter.

A direct tightly controlled encounter will usually result in the student's being very dependent on the instructor for the next move. In contrast, an indirect atmosphere in the encounter results in students being quite independent of the instructor for the next activities.

To design a self-paced teacher education program several steps were found to be essential.

First. Instructional materials had to be systematically designed with explicit behavioral goals and a specific relationship between each of the objectives and the instructional activities. The first Experimental Edition of the instructional modules developed by the Mathematics-Science Module Building Group in the R & D Center seem to fit this design so that seven were selected as the basis for self paced instruction of sequence. The modules used in the first sequence were:

"Observing the Basis of Science"

"Describing Observations"

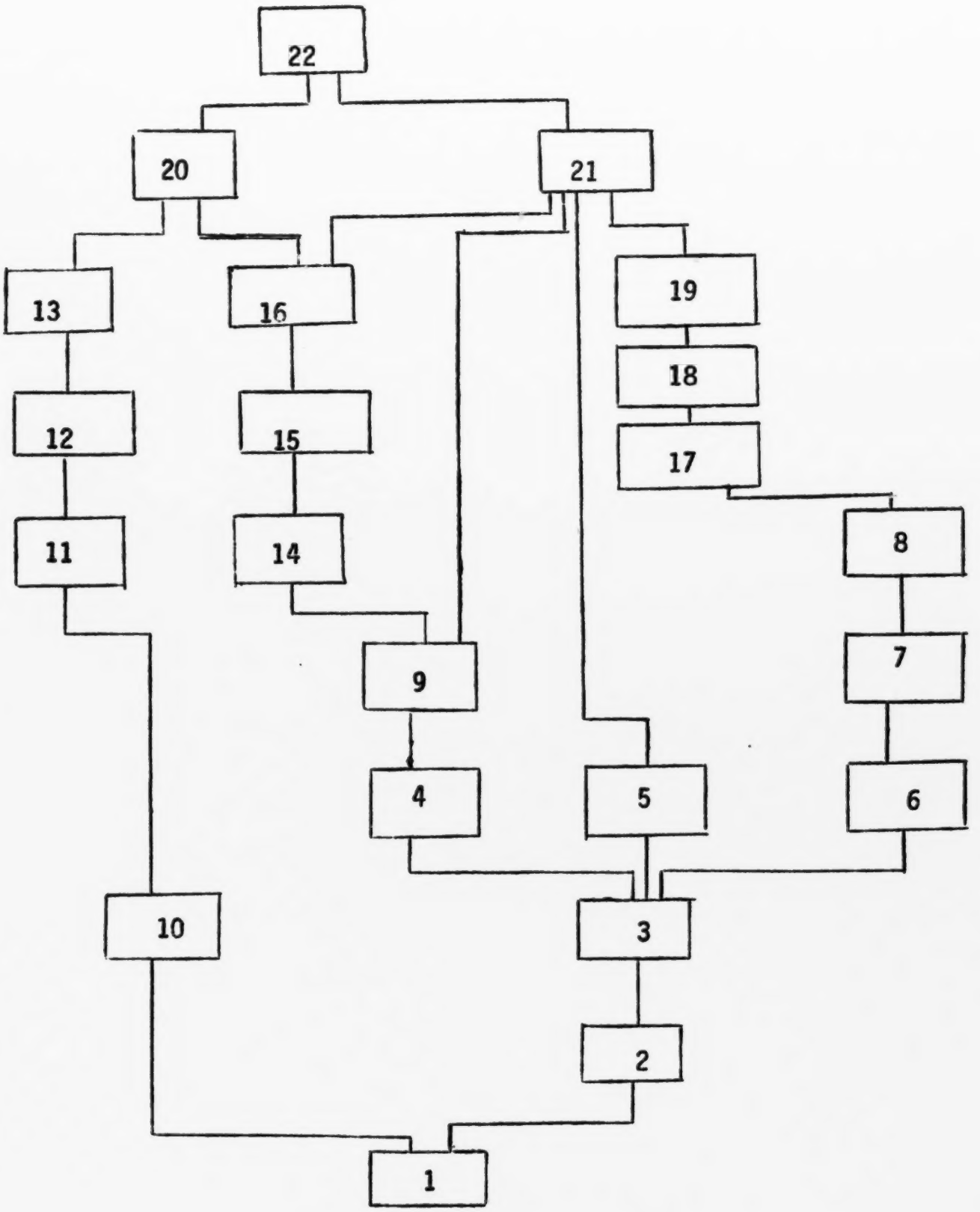
"Comparing Observations"

"Describing Events"

"Reasoning about Observations"

"Organizing to Investigate"

Second. The objectives for this set of instructional modules were listed on separate cards and sequenced in what appears to be the logical heirarchy. The logic of this heirarchy included both the interrelationships between the content of the objectives and the known concern levels of students. Figure 1 illustrates both the arrangement of the objectives and the related module topics.



KNOWLEDGE COMPETENCIES IN SCIENCE

Figure 1

Third. A self diagnostic test was essential so that each student could identify those tasks that he could do on entering the program. Test items were written for each objective on the heirarchy. A copy of this instrument was attached in Appendix A of this report.

Fourth. Knowing what he could already do was important to the student because it also revealed what he could not do. Designing the experiences to assist him in acquiring the competencies in what he could not do was the next task. For each of the blocks, or a combination of two of the blocks, task sheets were developed. Nineteen such sheets were developed for the twenty-two objectives. Each task sheet included:

A. Task objectives. A clear statement of the behavior the individual should be able to do by the end of that set of instructional activities.

B. Task focus. A pre-appraisal item that would have the student display the behavior described on the task sheet. A description of acceptable responses to this test item was also included in each task sheet.

C. Task activities. A series of activities in which the student had the opportunity to involve himself with manipulative materials or other media in acquiring the behavior described in the objectives. The step format of these sheets was carefully designed to provide sequential success for the student. Care was used to also provide many opportunities for open ended responses other than single word responses. Other opportunities were incorporated for the students to serve as the judge of the adequacy of his own response. As described by Dewey, he not only "goes" but "undergoes" each experience.

D. Task appraisal. When the student completed those activities which he disired to do, he was then directed to do the task appraisal--a post test situation in which he again displayed the behavior described in the objective. He was directed to have the appraisal scored by the instructor. Opportunities to redirect the student was possible at this point if he had not acquired the desired behavior.

Copies of the task sheets for the twenty-two objectives are attached in Appendix B.

The self paced versions of the instructional modules were piloted with a group of thirty individuals enrolled in a college course during the summer of 1969. Initially they were shown the profile sheet (see Figure 1) and were told that for this course, achievement through block number 19 would be graded as a B, and achievement through block 22 would be graded as an A. In the pretest any items which they could pass would be acceptable as satisfactory completion of that part of the course. Theoretically, it was possible for them to complete the course on the pretest. When the individuals completed the 19 or 22 objectives, they were finished with this course, regardless of how long or short a period of time it took them. The results of the pretest are shown in Table 1. For each student an individual file was established, and as they completed a task the block was marked with the date of completion. Figure 2 is an illustration of the student profile sheet.

Based on their performance record, Table 2 illustrates the rate of completion when students were pacing thier own activities. A parenthetical note is relevant at this point to note that the instruction and the group basis for these modules would have taken a minimum of 17 instructional days. No student

TABLE 1

STUDENT PERFORMANCE ON PRE-TEST

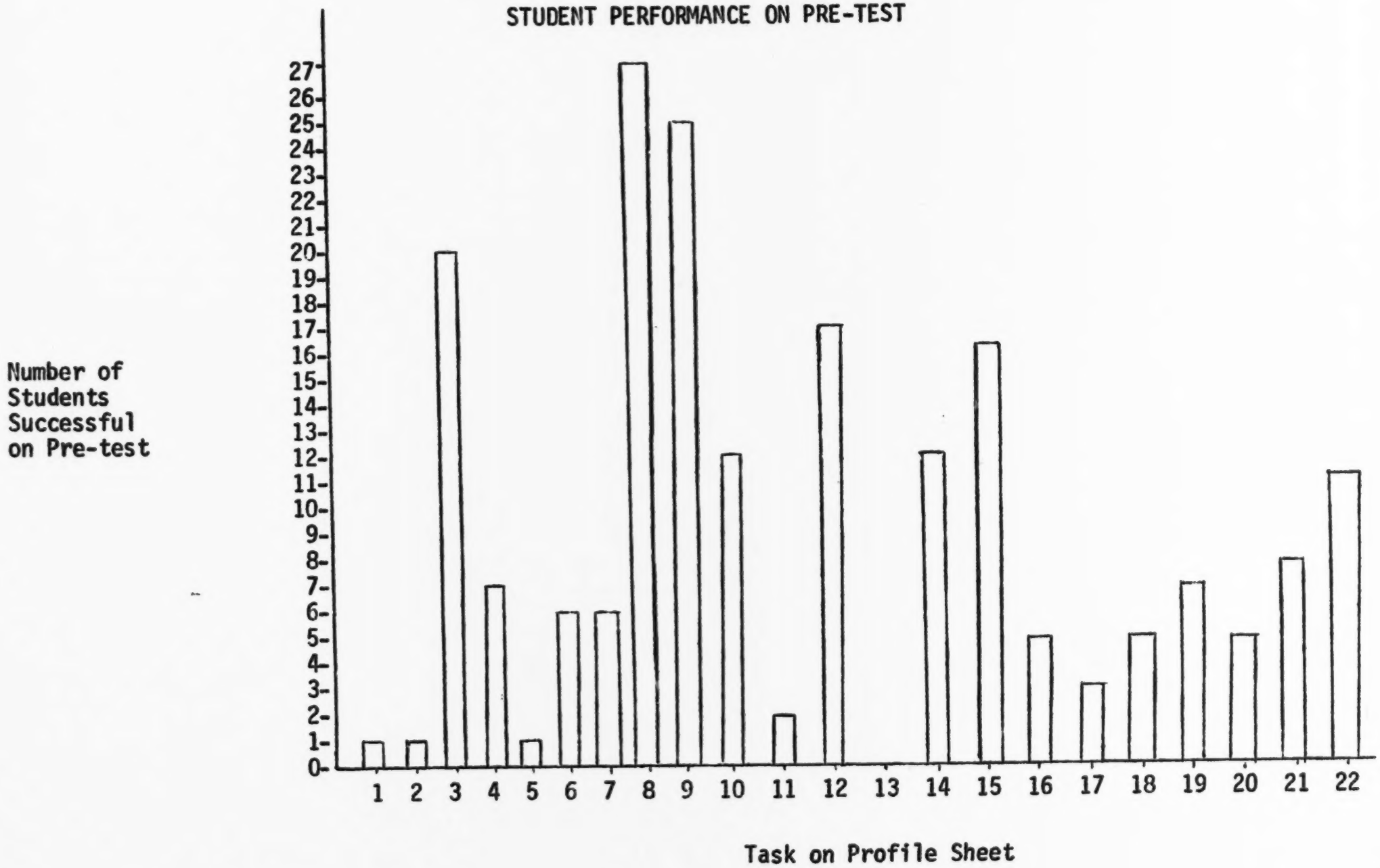
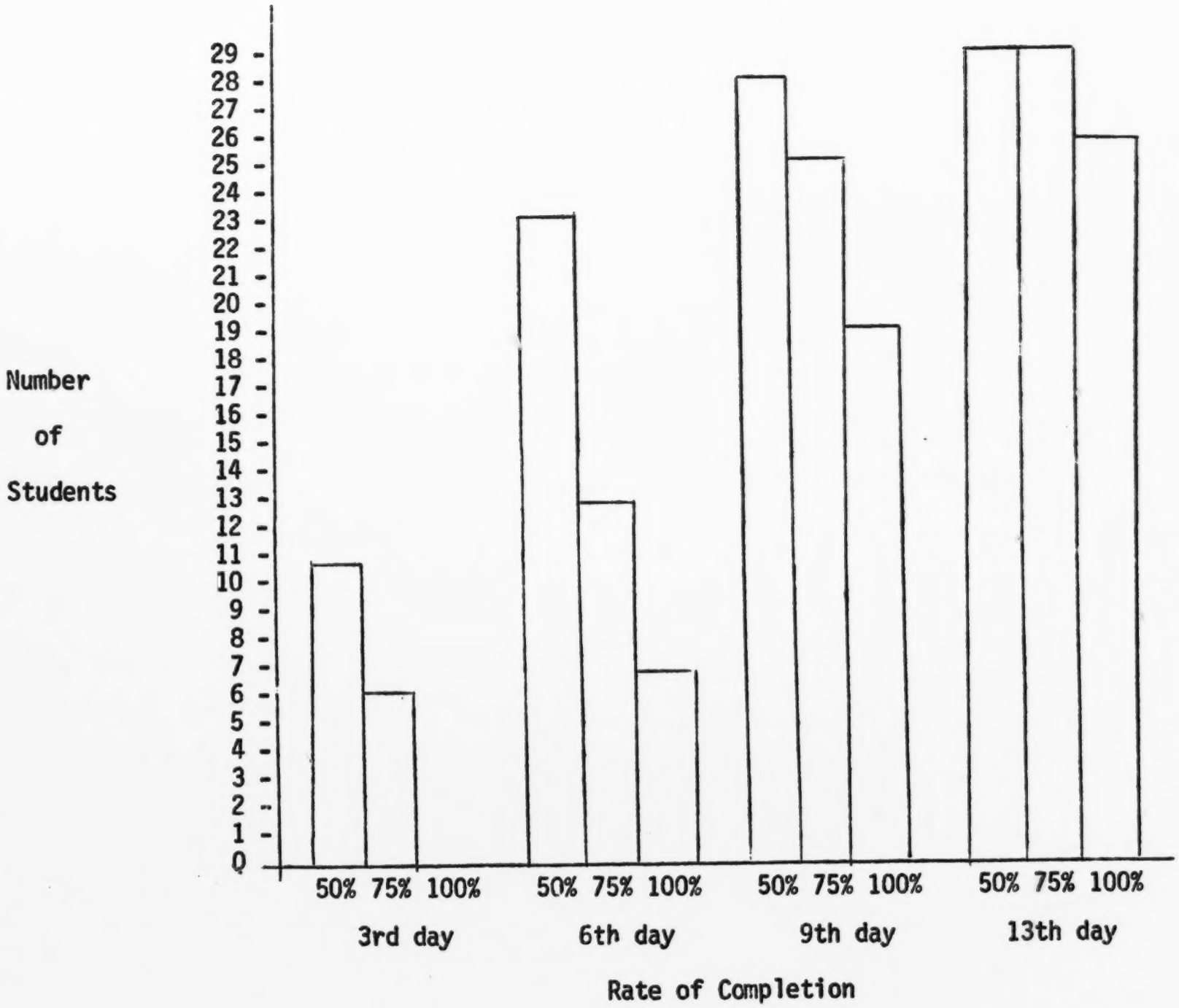


TABLE 2

RATE OF COMPLETION OF TASKS



found it necessary to take the entire 13 days of the course to complete the required tasks.

Summary.

Behavior change has been hypothesized to be effective when it is intentional and insightful. Providing which is paced by the student--in which achievement is the constant and time the variable--is one alternative to increase the probability of both the intent and insightfulness of instruction. In this preliminary report, self paced instructional modules and the result of the pilot testing of them with a group of 30 college students is described. Continued use of this pattern of instruction is planned during the 1969-70 school year.

APPENDIX A

PRE I

Code_____

PRE-APPRAISAL COMPETENCY TASKS

I.

Task I. Using the object given you, write 7 properties of the object.

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____

Task II.

1. Name the two-dimensional and three-dimensional shapes which are part of a Dr. Pepper bottle.

   Shapes: Two-dimensional_____

   _____

   Three-dimensional_____

   _____

2. By checking the appropriate column, identify the shape of the shadows cast by these objects:

a. cylindrical pill bottle					
b. base ball					
c. child's alphabet play block					
d. egg					
e. dunce cap					
f. cigar box					

Task III.

Examine the drawings of fruit. List only those characteristics of each sketch necessary to distinguish it from the others.

A. _____

B. _____

C. _____

D. _____

E. _____

Task IV.

In two classes, the children were listing their pets. The results were as follows:

Mrs. G's second-grade class

Pet	Number of Children Having One
Dog	11
Cat	9
Monkey	1
Parakeet	3
Gold Fish	4
Guinea Pig	1

Mrs. H's second-grade class

Dog	16
Cat	11
Parakeet	2
Monkey	3
Gold Fish	4
Guinea Pig	1

Construct a graph that shows the comparison of the results of the survey of pets in both classes.

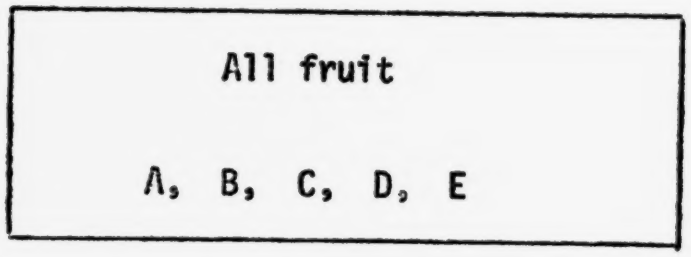
Which pet was the most popular? _____

Which pet was the least popular? _____

Task V.

Construct a classification system based on your descriptions in Task III.

The classification scheme you construct should be such that another person could use it to identify and name each of the fruits by using just the key you constructed and the transparency. At each stage in your system, name both the property used to separate the fruit and the name of the fruit that has the property.



Task VI.

Farmer Brown was planning to build a pen for his pigs. Some alternate plans for his pen are depicted on the following page.

1. Name two (2) properties common to the pens.

_____

2. Order the pens on the basis of area.

_____

3. Draw the longest straight line possible inside each pen. Now order the pens on the basis of the lines you drew.

_____

Task VII.

Attached are sketches of a Mung Bean Plant.

1. Describe three ways the developing plant can be compared on different days.

_____

_____

_____

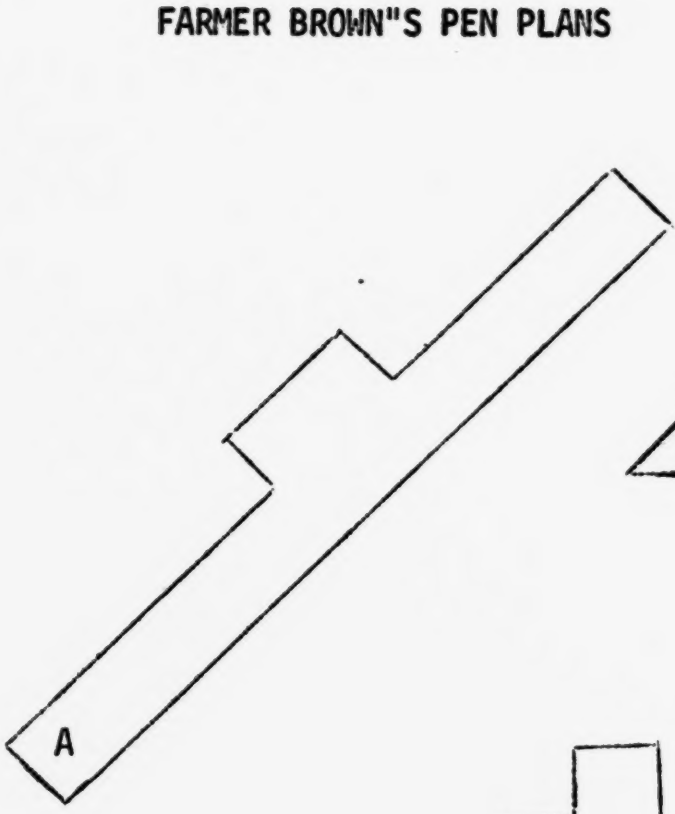
2. Describe the plant on the fourth day, using its appearance on another day as a unit of comparison.

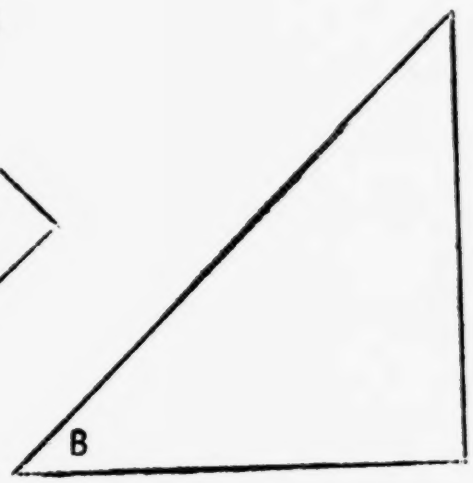
_____

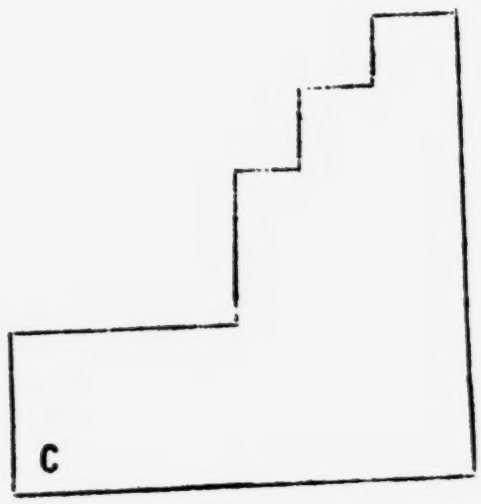
3. Describe the plant on the seventh day using a standard unit of comparison.

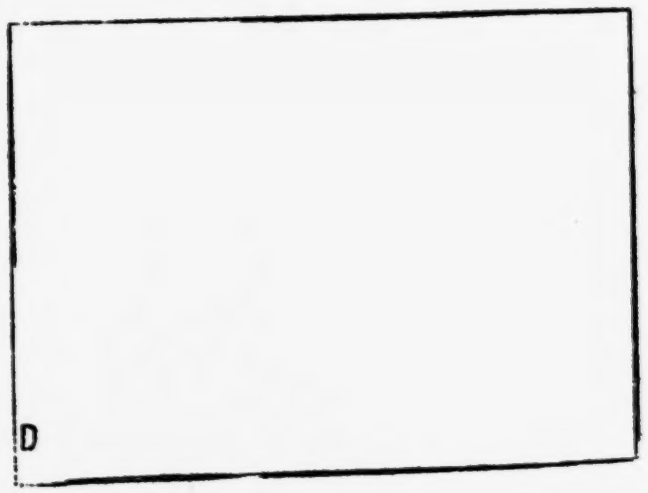
_____

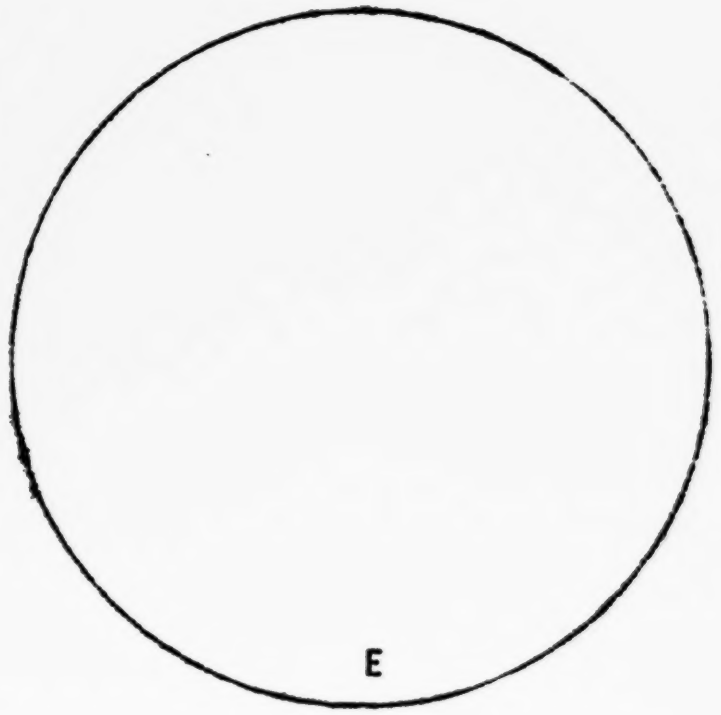
FARMER BROWN"S PEN PLANS

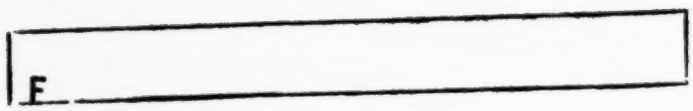












A full scale sketch of a Mung Bean Plant on successive days after planting.

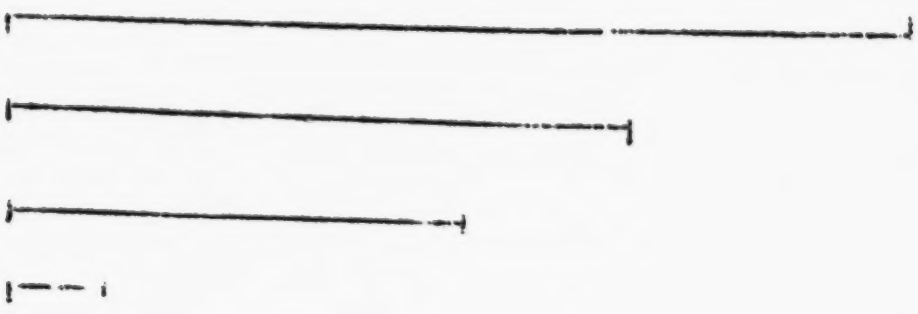
Days after planting.

Task VIII.

Use only your pencil--no other tools.

The line above is 10 cm in length. Estimate the length of the following:

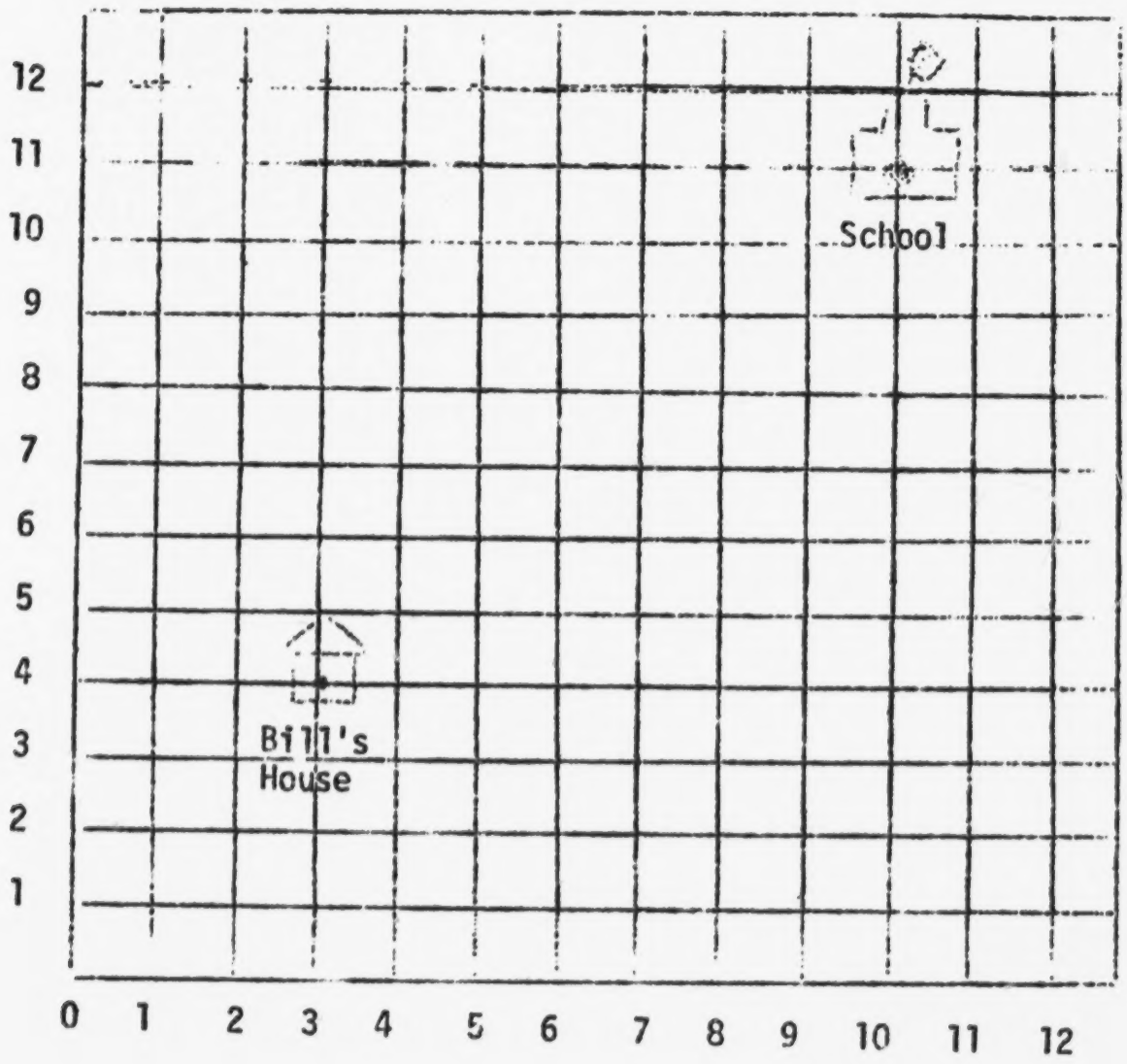
Which of these lines is closest to 5 cm in length?
Draw a circle around it.



Task IX.

Using the sketch on the following page, describe the location of

1. Bill's house _____
2. School _____



Task X.

Based on what you have seen in the filmed episode, please construct two (2) statements of <u>observation</u>:

1. _____

2. _____

Construct two (2) statements of <u>inference</u>:

1. _____

2. _____

Task XI Three children planted several lima bean seeds and then measured the height of the bean plants at selected intervals. As the seeds germinated, the three children made these observations:

A. One plant had larger green leaves than the other two.

B. The color of the leaves of the other two plants was light green to yellow.

C. The stems of the light green leafed plants were longer than the dark green leafed plants.

Write three inferences that would explain the differences between the plants.

Inference 1._____

Inference 2._____

Inference 3._____

Name the observations (A, B, C above) upon which your inferences were based:

For Inference 1._____

For Inference 2._____

For Inference 3._____

Task XII. Describe how you would test one of the inferences you constructed in Task XI.

Inference_____

Test_____

_____

_____

Task XIII. The children recorded their observations about the plants:

Days After Planting	Average Height of Plants at Tallest Point
4	1 cm
5 ½	5 cm
7	10 cm
11	23 cm
12½	28 cm

A. Construct a point graph of their data.
B. The manipulated variable in this activity was _____.
C. The responding variable in this activity was _____.
D. What do you think the average height of the bean plant was:
10 days after planting?_____.
8 days after planting?_____.
15 days after planting?_____.
3 ½ days after planting?_____.

Describe how you would find out if <u>one</u> of your predictions above was correct.

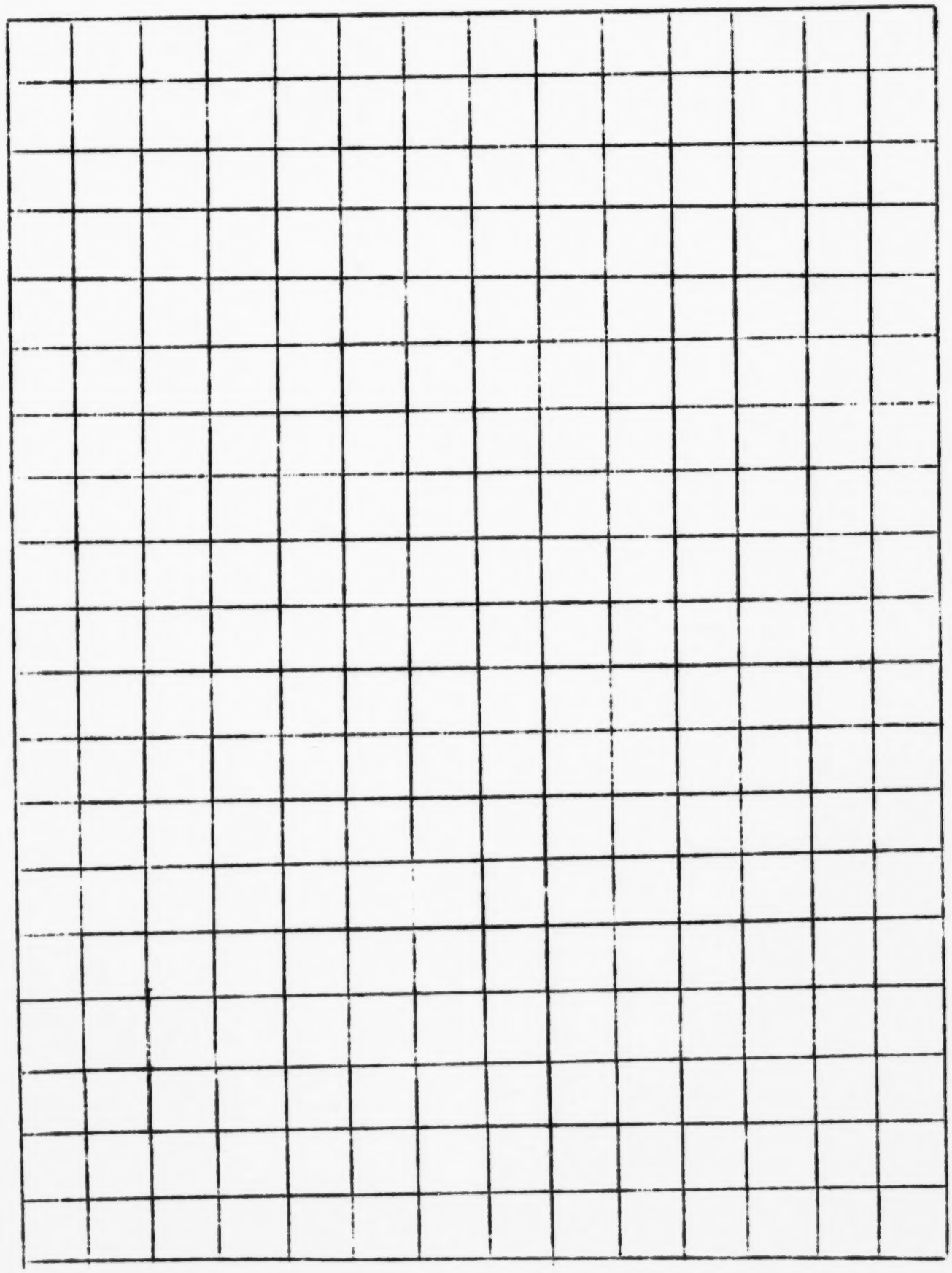
_____

_____

You made four predictions above. List them in order of greatest confidence you have that they are correct.

Most Confident Least Confident

_____ _____ _____ _____ _____



With your partner, now code each of your statements as follows:

1 Property observed by sight
2 Property observed by smell
3 Property observed by touch
4 Property observed by taste
5 Property observed by sound
6 A change in the cube
7 A measurement of the cube
8 An explanation or inference about the cube

Now make two more statements about the cube using each of the eight codes. (NOTE: Do not repeat statements made on first page.)

Code # 1 1.

2.

Code # 2 1.

2.

Code # 3 1.

2.

Code # 4 1.

2.

Code # 5 1.

2.

Code # 6 1.

2.

Code # 7 1.

2.

Code # 8 1.

2.

Your definition of observation is _____

_____

_____

You may wish to think more about observation in teaching science. A useful resource is Commentary for Teachers, page 35.

THE CUBE

Task Objective

At the end of this task, you should be able to:

Describe properties of an object or event by using all five of the senses.

Task Focus

In the materials you will find a book of matches. Remove one match from the book. List seven observable properties of that match.

1.
2.
3.
4.
5.
6.
7.

At the end of this task you will find acceptable answers to check yourself, Discussion of Task Focus p. 3.

Task Activity

Remove the cubes from the container. Place one about 1 meter from where you are sitting.

List four observable properties or characteristics of the cube.

1.
2.
3.
4.

Now name the cube--what is it?

5.

You may now examine the cube in any way you wish. You may also use the cup with water, the ruler, matches, or any other things that are available to you. List seven more observations of the cube.

6.
7.
8.
9.
10.
11.
12.

APPENDIX B

____ 5. The substance was hotter at Point C than at Point B.

____ 6. Between Points A and B the ice melted.

____ 7. Between Points B and C the temperature changed.

____ 8. At Point C the water boiled.

____ 9. At Point D the water was boiling.

Construct a systematic analysis of the experiment.

Event	Objects in System
When a constant source of heat is added to ice, change occurs.	1. 2. 3. 4. 5.

Task XVIII. Given the event described in your analysis of Task XXI, state one question which you could investigate further.

_____

_____

_____

What specifically would you do to find the answer to your question?

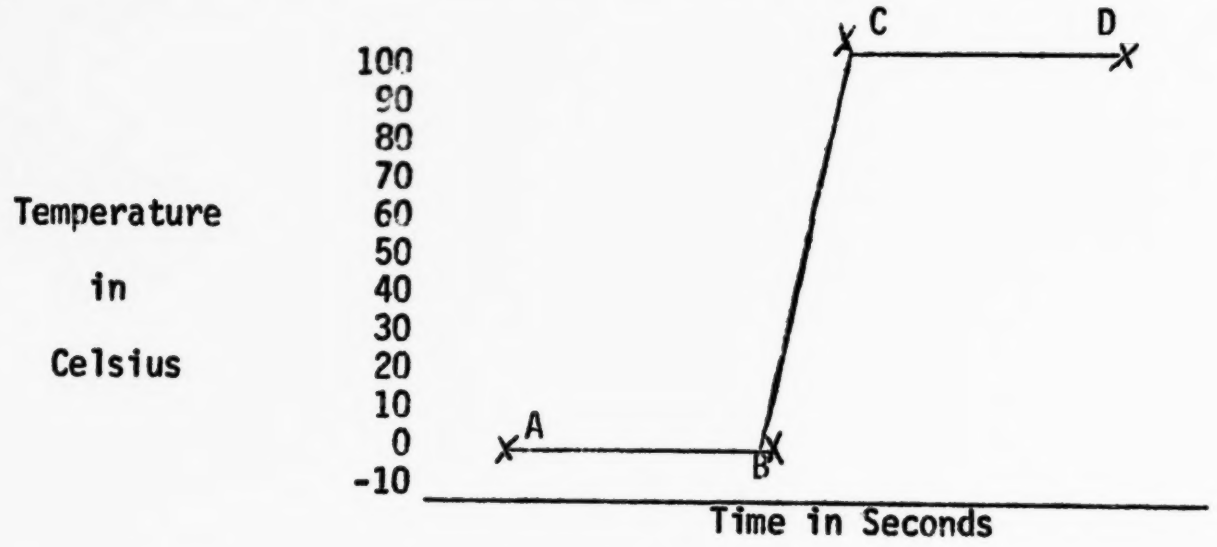
_____

_____

_____

_____

Task XVII. A hot plate has been pre-heated for 5 minutes. The temperature switch of the hot plate remained at the same setting during the experiment described below. The experiment involved a pan of ice cubes which were placed on the hot plate. The temperature was recorded every 30 seconds, and the results when graphed looked like this:



TASK I:

Based on the information given, code the statements in the following lists with

__F__ for those that are Facts from the graph.

__I__ for those which are Interpretations from the graph.

_____ 1. The temperature was the same at Point B as it was at Point A.

_____ 2. The hot plate was turned on "high".

_____ 3. The ice disappeared at the time of Point B.

_____ 4. The temperature was the same at Point D as at Point C.

Task XVI. An escalator in a department store was moving up at 20 steps per minute. Several children are having fun going up and down on the up escalator. One boy found out that he could run on the escalator at 10 steps per minute. Answer the following questions and draw arrows to show how you found your answer:

a. What is the boy's velocity, relative to the foot of the escalator at 10 steps/minute?

Answer_____

Describe how you could find out using arrows:

b. What is the boy's velocity, relative to the foot of the escalator, when he runs down (on the up escalator) at 10 steps/minute?

Answer_____

Describe how you could find out using arrows:

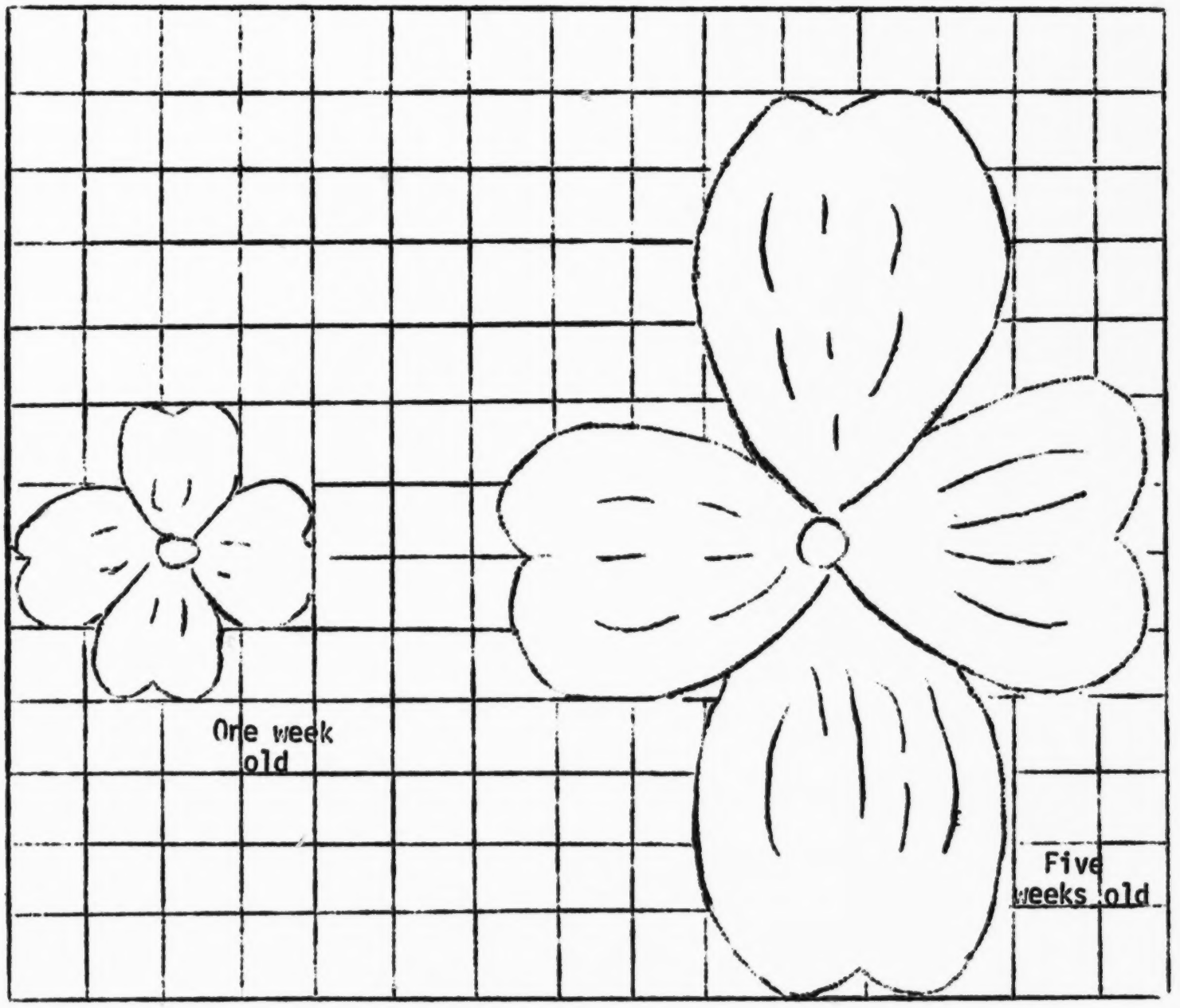
c, What is the boy's velocity, relative to the foot of the escalator, when he runs down (on the up escalator) at 20 steps/minute?

Answer:_____

Describe how you could find out using arrows:

Task XV.

Here are two diagrams of a dogwood blossom at two different ages: one week and five weeks.



Describe the observable changes of the diagram of the blossom from one week of age to five weeks of age.

_____

Compute the rate of change for 2 properties of the blossom.

_____

_____

State the rule for computing the rate of change of a property of an object.

_____

Task XIV The hare and the tortoise were practicing for a race. The hare jogged 4 units north and the tortoise 2 units south. They both started from the same point and ended their jog at the same time. Draw arrows to describe their displacement and velocity.

Displacement Arrows

Velocity Arrows

The next day's practice was a repeat over the same course. The hare ran in 4 minutes and the tortoise in 2 minutes. Draw arrows to describe displacement and velocity on this day.

Displacement Arrows

Velocity Arrows

You are now ready for the Competency Appraisal. When you complete this, please have it scored by the instructor.

Discussion of Task Focus

Your list should include:

1. Only observable properties and not inferences as to the composition of the match or how it was made.

2. The use of at least four of the five senses.

Some possible responses are:

1. It looks like paper.
2. It smells like a match.
3. It is brown in color.
4. It has different substances at one end than at the other end.
5. It tastes bitter.
6. It produces a scratching sound when struck against something.

COMPETENCY APPRAISAL

Using the object given you, write 7 properties of the object.

1. _____

2. _____

3. _____

4. _____

5. _____

6. _____

7. _____

SHAPES AND SHADOWS

Task Objective

At the end of this task you should be able to:

Identify and name two-dimensional and three-dimensional shapes as part of objects in your environment.

Task Focus

In the materials, you will find a toy.

1. Name the two-dimensional shapes which are part of that toy.

_____

_____

2. Name the three-dimensional shapes which are part of that toy.

_____

_____

3. Is the toy symmetrical? YES_____ NO_____
Describe how you would show someone the reason for your answer.

_____

_____

_____

You may wish to check your answers with the Discussion of Task Focus on page 4.

Task Activity

Look for the pictures of farm animals on display in this room. Individually you and your partner make a list of the things that have a gizmo on top of one of their ends.

1.
2.
3.
4.

Do your lists agree?

Why?

Now identify each animal that has a cone-shaped projection on its head.

1.
2.
3.
4.

Do your lists agree this time?

Why?

What was the difference in the "Gizmo" task and the "Cone-shaped projection" task?

Take out Packet A of the materials. Identify the shapes in the Packet. (Note: Packet A includes both the envelope and box.)

A. Circle
B. Square
C. Ellipse
D. Triangle
E. Rectangle
F. Sphere
G. Cube
H. Cone
I. Pyramid
J. Rectangular parallelopiped or Rectangular Prism
K. Cylinder

For each shape, name three objects in the room that has a shape like the one in the packet.

Shape A 1.
2.
3.

Shape B 1.
2.
3.

Shape C 1.
2.
3.

Shape D 1.
2.
3.

Shape E 1.
2.
3.

Shape F 1.
2.
3.

Shape G 1.
2.
3.

Shape H 1.
2.
3.

Shape I 1.
2.
3.

Shape J 1.
2.
3.

Now place the cube on the overhead projector. With the light turned on, what is the shape of the shadow on the screen?

How many different shaped shadows can you get from the cube?

Describe the different shadow shapes you get with

a cone

a pyramid

a rectangular prism

a cylinder

What is the fewest number of shadows you must have in order to know that the object is

a cone

a pyramid

a cylinder

an ellipsoid

How are shapes and shadows related to teaching science to children?

Now take out the materials in Packet B. With your partner, arrange them in two groups.

What is the basis of your grouping?

Now put the Letter J and Letter S and the pumpkin and pear in one group. In what way are all these objects alike?

Print all the letters of the alphabet on the following lines:

_____

_____

Circle those letters that have matching halves. What is the name for an object that has a matching half?

Look back at the group of all objects other than letter J, S, and pumpkin and pear. Suppose you were to put the hexagon, octagon, ellipse, triangle, and letter X in one group. In what way is their symmetry different from that of the other objects?

How is symmetry related to teaching science to children?

If you wish to read more about shapes, shadows, and symmetry, see pages 40-58 of the Commentary for Teachers.

You are now ready for the Competency Appraisal. Please have the instructor score it as soon as you are finished.

Discussion of Task Focus

The two-dimensional shapes include circle in the wheel, rectanglar shaped body, and triangles in the window.

The three-dimensional shapes include the ellipsoid shaped body and cylinders for wheels or axle.

The car is symmetrical and your description of why this is so should include the idea that it could be divided so that two sides of it match.

COMPETENCY APPRAISAL

1. Name the two-dimensional and three-dimensional shapes which are parts of a sharpened primary pupil's round pencil.

   Two-dimensional _____

   _____

   Three-dimensional _____

   _____

2. Identify, by checking the appropriate column, the two-dimensional shapes which are parts of the following three-dimensional figures:

a. cylinder					
b. sphere					
c. cube					
d. ellipsoid					
e. cone					
f. rectangular parallelepiped					

TINKERING WITH TINKERTOYS

Task Objective

At the end of this task you should be able to:

> Name the minimal observable properties of an object or an event necessary to distinguish it from similar objects or events in a set.

Task Focus

Examine the objects in Packet X. List only (1 or if necessary 2) those characteristics sufficient to distinguish each object from the other.

Object_____ Characteristic_____

_____

Object_____ Characteristic_____

_____

Object_____ Characteristic_____

_____

Object_____ Characteristic_____

_____

Object_____ Characteristic_____

_____

On Page 2 you will find a discussion of the acceptable responses.

Task Activity

In the materials, you will find two Packet C's. Place yourself with your back to your partner. Both of you should take out all of the tinkertoys in Packet C. Without looking at your partner, construct an arrangement of four of the tinkertoys and describe what you did so that your partner can make the same kind of arrangement.

You may find it useful (and fun) to repeat this two or three times.

Did you experience any difficulties?

What were they?

What did you do to improve your descriptions?

Now face your partner. Arrange the three-dimensional shapes on the table between you and play the "More Information Please" game.

The rules for this game are:

1. You may give only one specific bit of information in the task.
2. Your partner may only point to an object if the information is sufficient to identify it from all others.
3. If your partner cannot point to an object, he says "More Information Please", then have your partner tell you why more information is needed.

For example, look at the objects and select one that has a point on it. (Do you need more information?)

Select one that has straight sides. (Do you need more information?)

Select one that has square corners. (Do you need more information?)

Select one that has only square surfaces. (Do you need more information?)

Continue to practice this together with the shapes or other objects in the room.

In what way is this set of activities related to teaching science to children?

You are now ready for the Competency Appraisal. Please have the instructor score this as soon as you are finished.

Discussion of Task Focus

A key idea here is that the characteristic describes how each object is unique; that is, one or two ways in which it is different from all the other objects in the group.

washer - circular, has a hole

nail - one pointed end

cap - circular, has no hole

clamp - has a hole, not circular

jack - 2 pointed ends

COMPETENCY APPRAISAL

Examine the drawings. List only those characteristics of each sketch necessary to distinguish it from the others.

3. _____

10. _____

15. _____

34. _____

20. _____

18. _____

35. _____

GRAPHS

Task Objective

At the end of this task you should be able to:

Construct a graph for pairs of observations.

Task Focus

Two children were counting the number of different kinds of cars that went by the front of their house in the morning and at noon. They counted all the cars for 15 minutes at 8:30 and repeated this at noon. The results looked like this:

	8:30	12:00
Buick	16	18
Ford	29	18
Chevrolet	24	12
Plymouth	19	6
Pontiac	21	17
Trucks	4	4

Construct a graph that shows a comparison of the count at 8:30 and at noon. Use page 2.

On page 11 you will find a discussion of acceptable responses.

Task Activity

Take out the objects in Packet D. How many of them have a shape

a. like a circle?_____
b. like a triangle?_____
c. like a square?_____
d. like an ellipse?_____
e. like a rectangle?_____

Suppose you were to communicate there results to someone who could not hear or read words. How might a graph help?

What information or story should the graph tell?

What information must be on the graph?

Using the graph paper, page 4, what will you use as the labels for the horizontal axis, i.e., the base line? (The choice is arbitrary, but it is customary to use that set of categories you select for the base line and the set of categories that you count or measure for the vertical axis.)

Label your two axes.

(By the way--do you label the lines or the spaces?) Custom says label lines only. What do you think might be the reason for that rule?

Now complete your graph.

Let's get some more information.

Write down the name of

1. Your Governor _____
2. One U.S. Senator from your state _____
3. The mayor of your town _____
4. The Secretary of Defense _____
5. The Chief Justice of the Supreme Court _____
6. The mayor of New York City _____

In one group the results were as follows:

Out of 26 individuals,

24 named the Governor
25 named the Senator
26 named the mayor
11 named the Secretary of Defense
4 named the Chief Justice
18 named the mayor of New York

Add the results of you and your partner to this data and construct a graph of this information of important people today. Use page 5

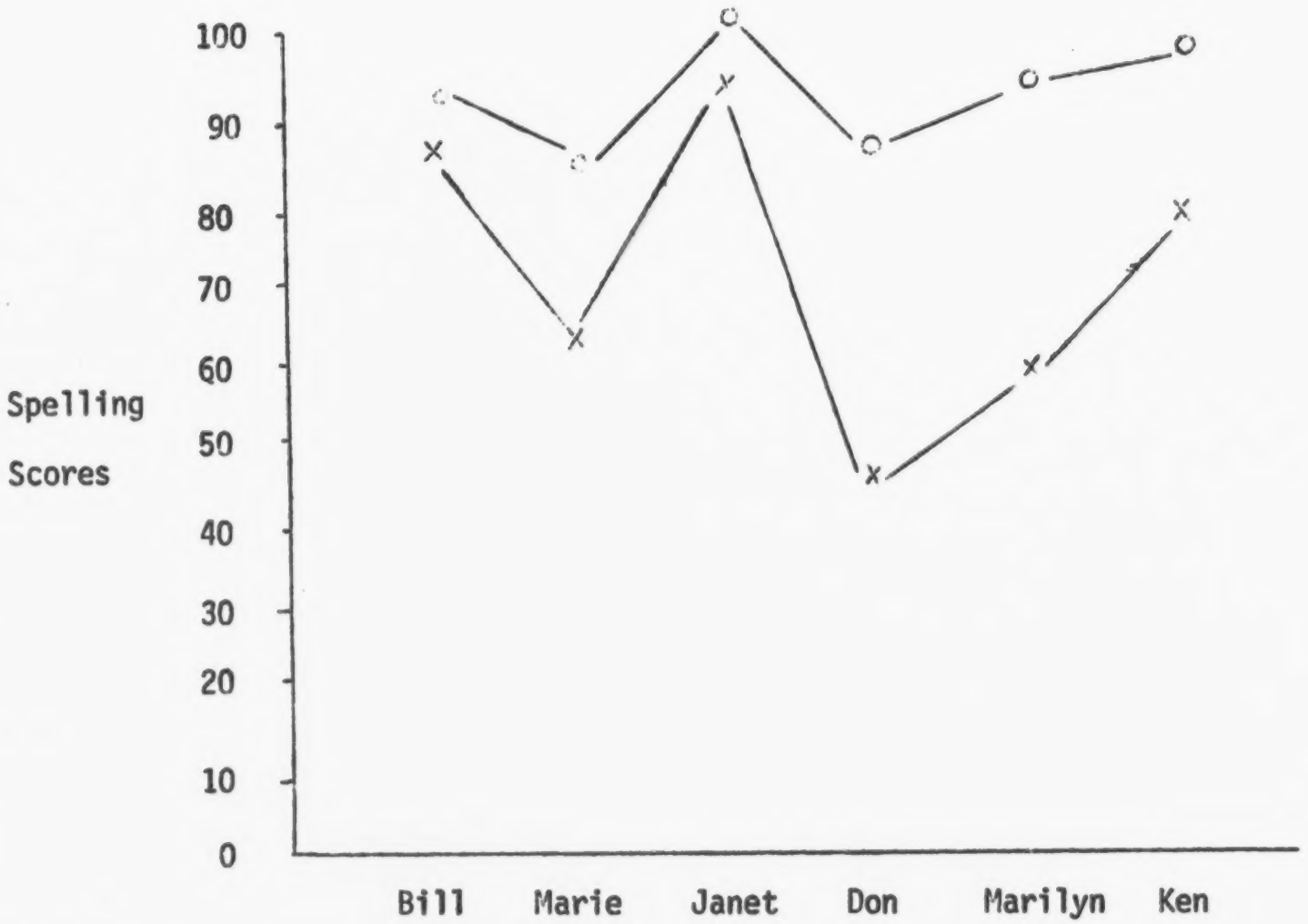
On DO #4 you will find a set of data showing the results of student achievement scores in spelling between the first test and the last test during a time when the teacher used a new approach to spelling.

Construct your graph which you think will best communicate how effective this new approach to spelling was. Use page 7.

Miss Ima Genius's Class Spelling Achievement

Child	January	March
Bill	89	91
Marie	61	82
Janet	86	93
Don	40	81
Marilyn	50	84
Ken	72	88

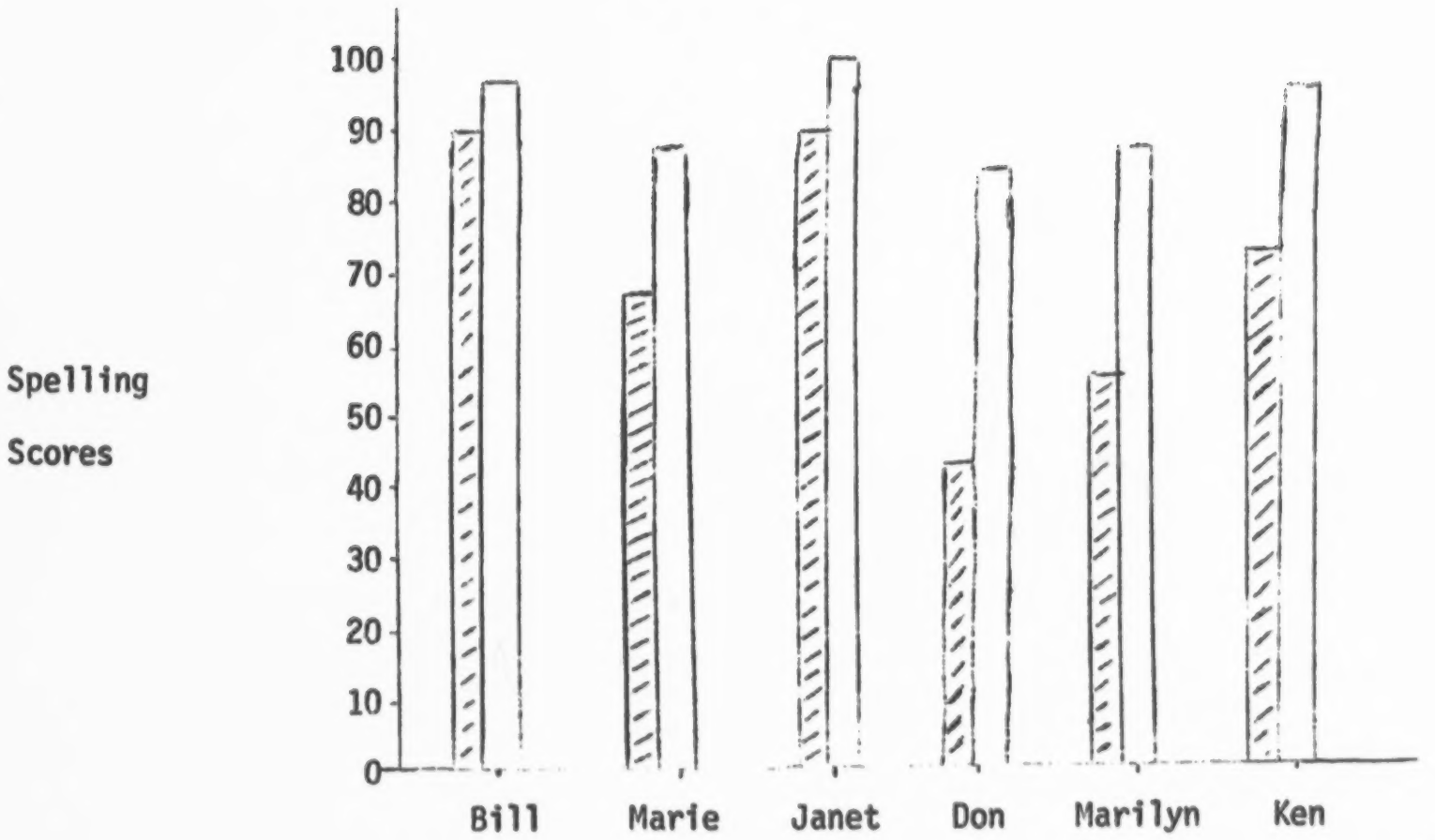
Now look at the following 3 graphs:

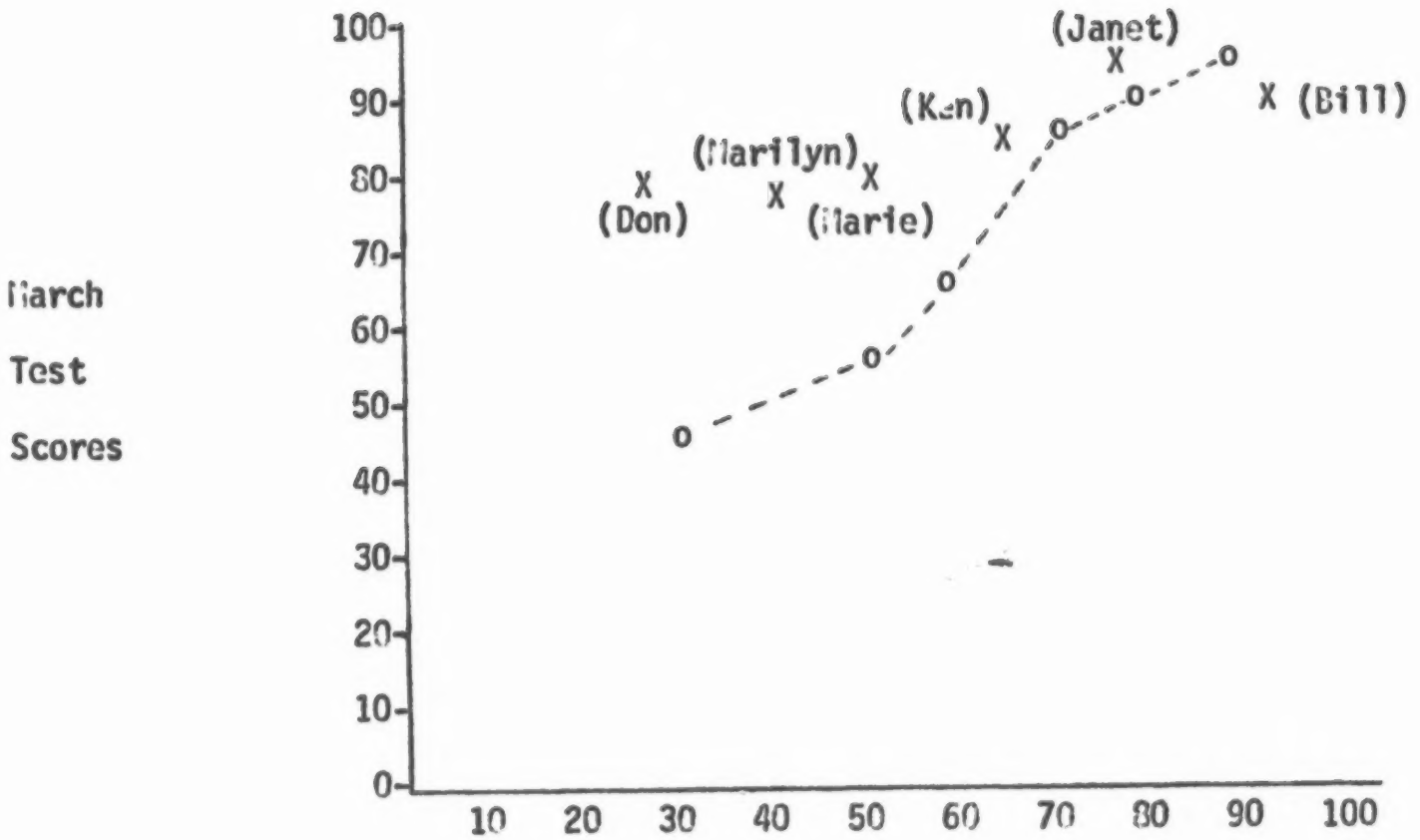


January and March Spelling Scores

X = January score

O = March score


Spelling
Scores
100
90
80
70
60
50
40
30
20
10
0
Bill
Marie
Janet
Don
Marilyn
Ken
STUDENT
January and March Spelling Scores
= January score
= March score



o = what was expected if all students were helped the same by the new spelling approach

X = what was observed.

Which graph is like yours?

On each of these graphs, write a single sentence which describes what you think the graph best pictures.

You have just constructed several graphs.

A. What kind of categories do you place on the base line?

B. What kind of categories do you place on the vertical axis?

C. Why are categories placed on the line and not on the space?

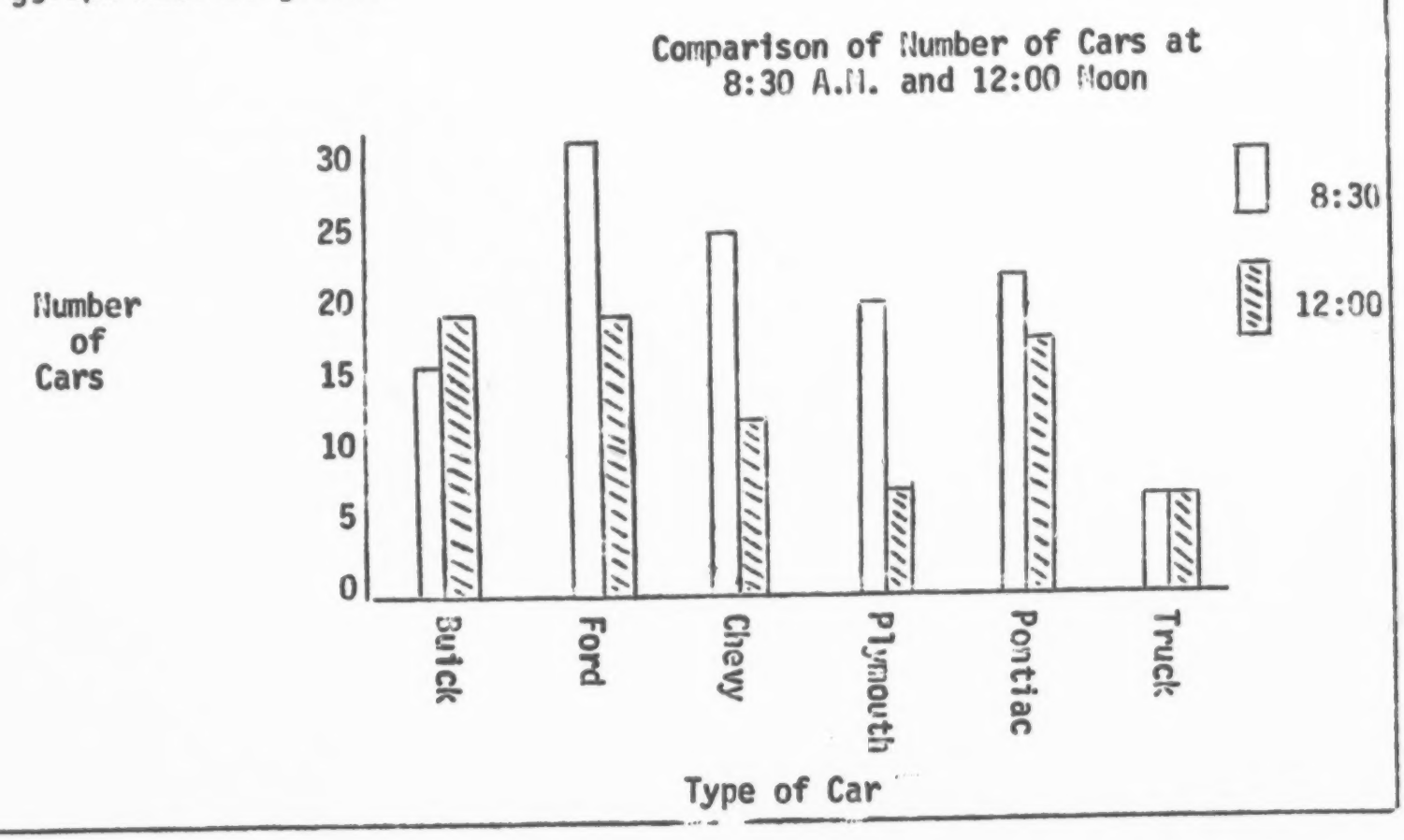
In what way is graphing related to teaching science?

If you wish to read more about graphs, please see pages 112-134 of the Commentary for Teachers.

You are now ready for the Competency Appraisal. Please have the instructor score it as soon as you are finished.

Discussion of Task Focus

Note in the grpph both sides must be labeled and a title for the ggraph must be given.



COMPETENCY APPRAISAL

The teacher in two fourth-grade classes made a survey of the students' opinion of the cafeteria menu. The results were as follows:

Mrs. M's Class

Menu	Number of Students Who Approved
Hamburger	29
Meat Loaf	26
Coney Sticks	18
Chicken Legs	21
Fish Sticks	8

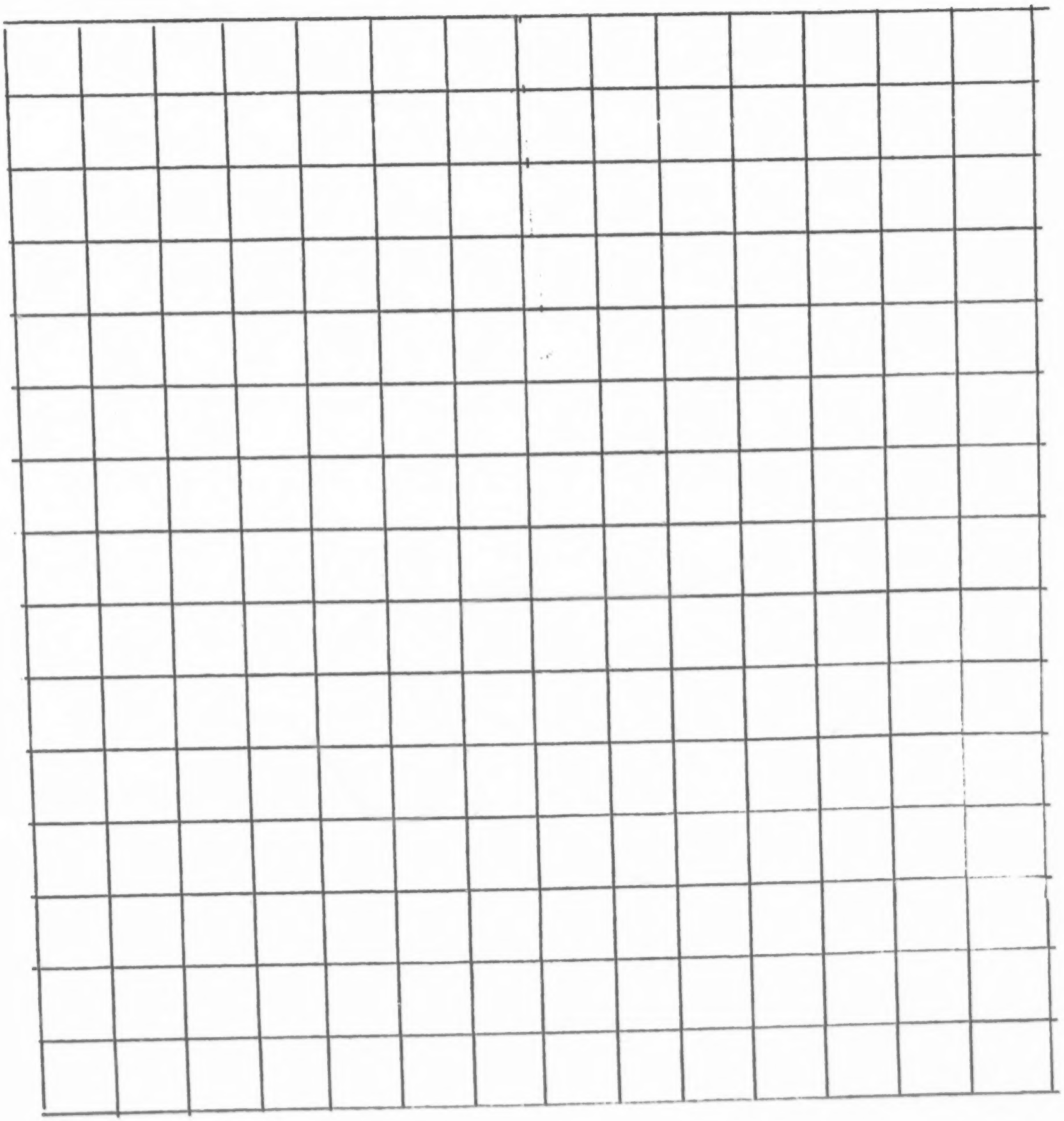
Mrs. W's Class

Hamburger	28
Meat Loaf	24
Coney Sticks	30
Chicken Legs	18
Fish Sticks	4

Construct a graph that shows the comparison of the results of the survey in both classes.

Which food did the children prefer? _____

Which food was preferred the least? _____



VEGETABLES AND OTHER STUFF

Task Objective

At the end of this task you should be able to

Construct a two- or more stage classification of a set of objects based on observable properties.

Task Focus

Here is a description of the objects in Packet X.

washer - has a hole, circular
clamp - has a hole, not circular
cap - has no hole, circular
nail - one pointed end
jack - two pointed ends

Construct a classification system based on these descriptions. Your system should be such that your partner could use it to identify and name each of the objects in the packet using only your key. At each stage, name both the characteristics and the objects in that group.

On page 3, you will find a discussion of acceptable responses.

Task Activities

Take out box D of the materials, but do not open it.

While your partner times you, look inside the box for only 15 seconds. Now list all the objects you saw inside the box.

Repeat this task letting your partner look inside for 15 seconds and then make a list.

Compare the two lists.

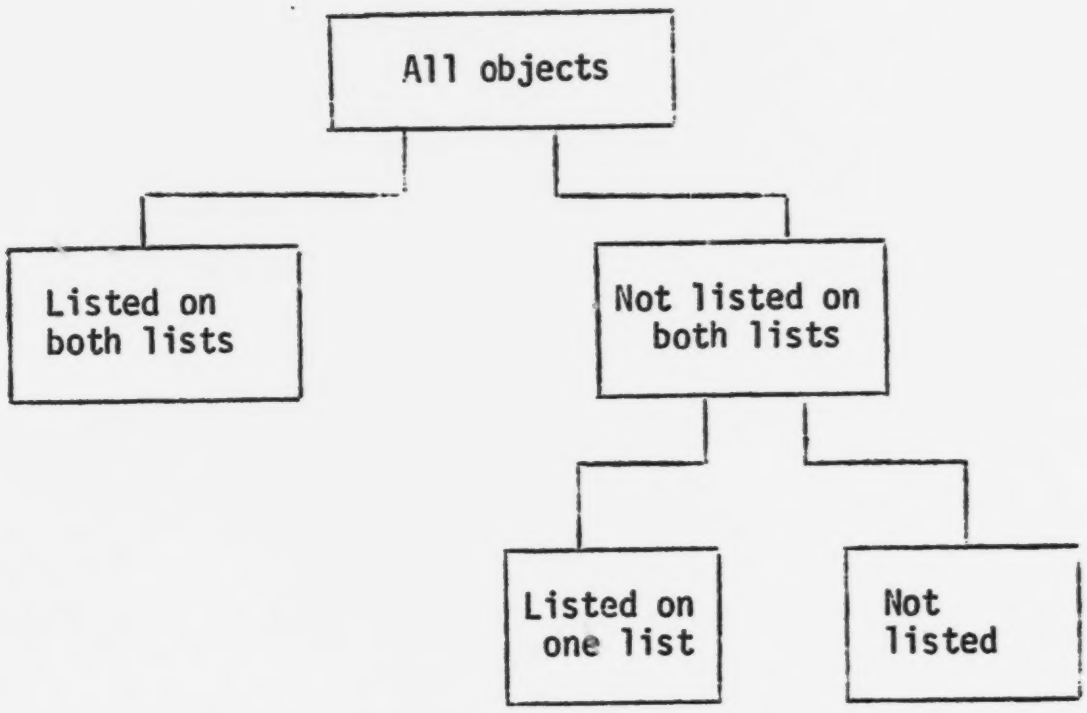
How many objects did each of you list?

How many objects were on both of your lists?

How many objects were on only one of your lists?

Now open the box and check your lists. What items do you now need to add to them?

Group your objects according to this scheme.



Now place all the objects in a large circle on the chart paper. Name the circle so that it will include all the objects.

Group the objects into two groups and name the characteristic common to each group on the chart.

Continue the sub-grouping until you have each object in a separate circle.

Identify where these objects would now fit into your scheme.

1. a pencil
2. a chalkboard eraser
3. a dime
4. a thumbtack

Some useful keys in classifying are:

1. Each time you regroup, select a characteristic shared by about half of the total group of objects.

2. Make sure that your groups are mutually exclusive, such as
   Blue - Not Blue rather than Blue - Red or
   Round - Not Round rather than Round - Square.

In the room there is a set of plastic vegetables on display. Use only those characteristics that are observable and construct a classification key for the entire set of vegetables.

List the characteristics you used.

Show on your chart what you would do to add

1. a green pepper
2. an orange

In what way does classifying help you to describe?

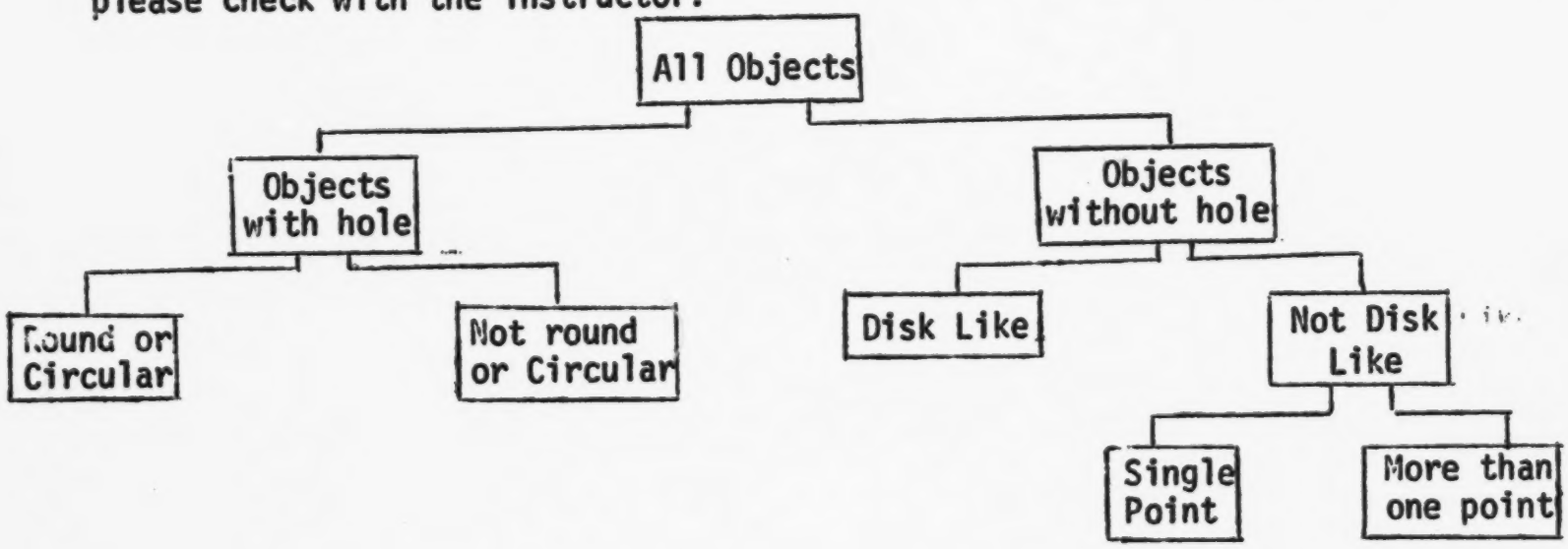
How is classifying related to teaching science?

If you wish to read more on classifying please see pages 58-71 of the Commentary for Teachers.

You are now ready for the Competency Appraisal. Please have the instructor score it as soon as you are finished.

Discussion of Task Focus

Several keys are possible for this task. If you are needing help, please check with the instructor.



COMPETENCY APPRAISAL

Construct a classification system of the objects, based on your descriptions in Task III.

The classification scheme you construct should be such that another person could use it to identify and name each of the objects by using just the key you constructed and the transparency. At each stage in your system, name both the property used to separate the objects and the number of the object that has the property.

All Objects
3, 10, 15, 34, 20, 18
35

ORDERING

Task Objective

By the time you have completed this task you should be able to

> Order objects by comparing a property which the objects have in common (such as length, area, volume, or mass).

Task Focus

On the following page is an outline drawing of a series of lakes along a river. Name two properties or characteristics common to all the lakes.

1.

2.

Order the lakes on the basis of area.

(largest) 1.
2.
3.
(smallest) 4.

Suggested answers are on page 4.

Task Activities

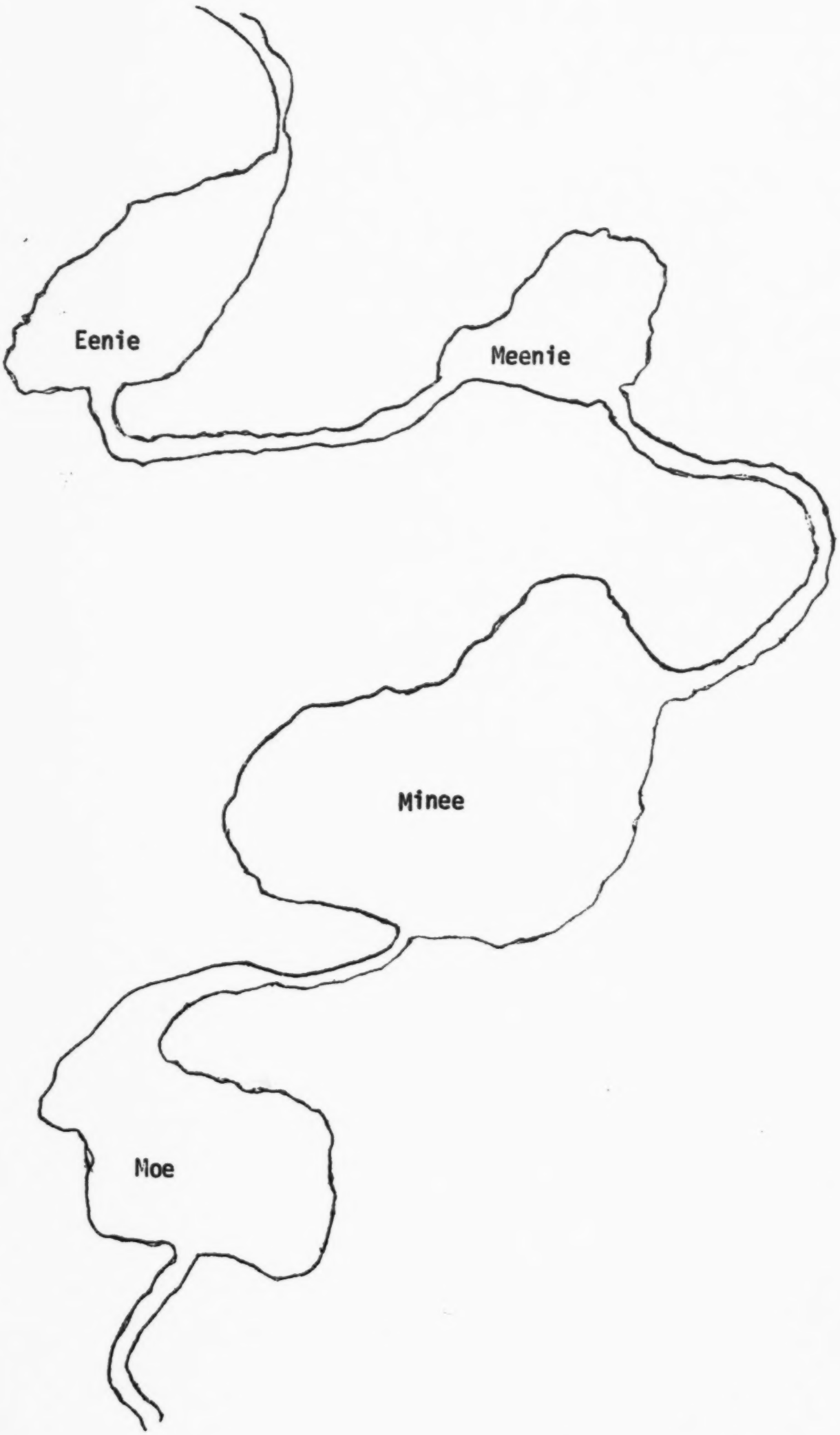
Remove the objects from Packet A and write down eight items to describe these objects.

1.
2.
3.
4.
5.
6.
7.
8.

Look back at your list and circle each descriptive item that indicates that you either did or could compare the objects with each other.

List four other types of comparisons of the straws that could be made.

1.
2.
3.
4.


Eenie
Meenie
Minee
Moe

Suppose we use length as the type of comparison. Order the straws by length.

Does your arrangement agree with your partner?

Which straw did you use as your basis for comparison?

Using the longest straw as the basis of comparison, describe the other straws, such as

1. The shortest straw is _____ as long as the longest straw.
2. The next straw is _____ as long as the longest straw.

Using the shortest straw as the basis of comparison, describe the other straws.

1. The longest straw is _____ as long as the shortest straw.
2. The next straw is _____as long as the shortest straw.

What is the difference in using the longest or the shortest straw as the unit of comparison?

Remove the containers from Packet B. Which one will hold the most water?

Which one will hold the least water?

Order the containers from most to least volume.

Describe how you could find out how much more each container holds than the next smaller size.

_____
_____
_____

Describe the volume of the smallest container using the largest container as your unit of comparison (or your measuring unit).

_____
_____

Describe the volume of the largest container using the smallest container as your unit of comparison.

_____

_____

In one sentence, describe how these tasks relate to measuring.

If you wish to read more about measuring, please see page 102 of the Commentary for Teachers.

You are now ready for the Competency Appraisal. Please have the instructor score it as soon as you finish.

Discussion of Task Focus

1. Some properties you could have described are:

   area
   longest length across the lake
   shortest length across the lake
   volume of the lake

2. From largest to smallest area:

   a. Minee
   b. Moe
   c. Eenie
   d. Meenie

COMPETENCY APPRAISAL

A contractor was planning to subdivide a new area of the county. Some alternate plans for his subdivision appear on the following page.

1. Order the tracts on the basis of the amount of area of each tract.

   _____

2. Draw the longest straight line possible inside each tract. Now order the tracts on the basis of the lines you drew.

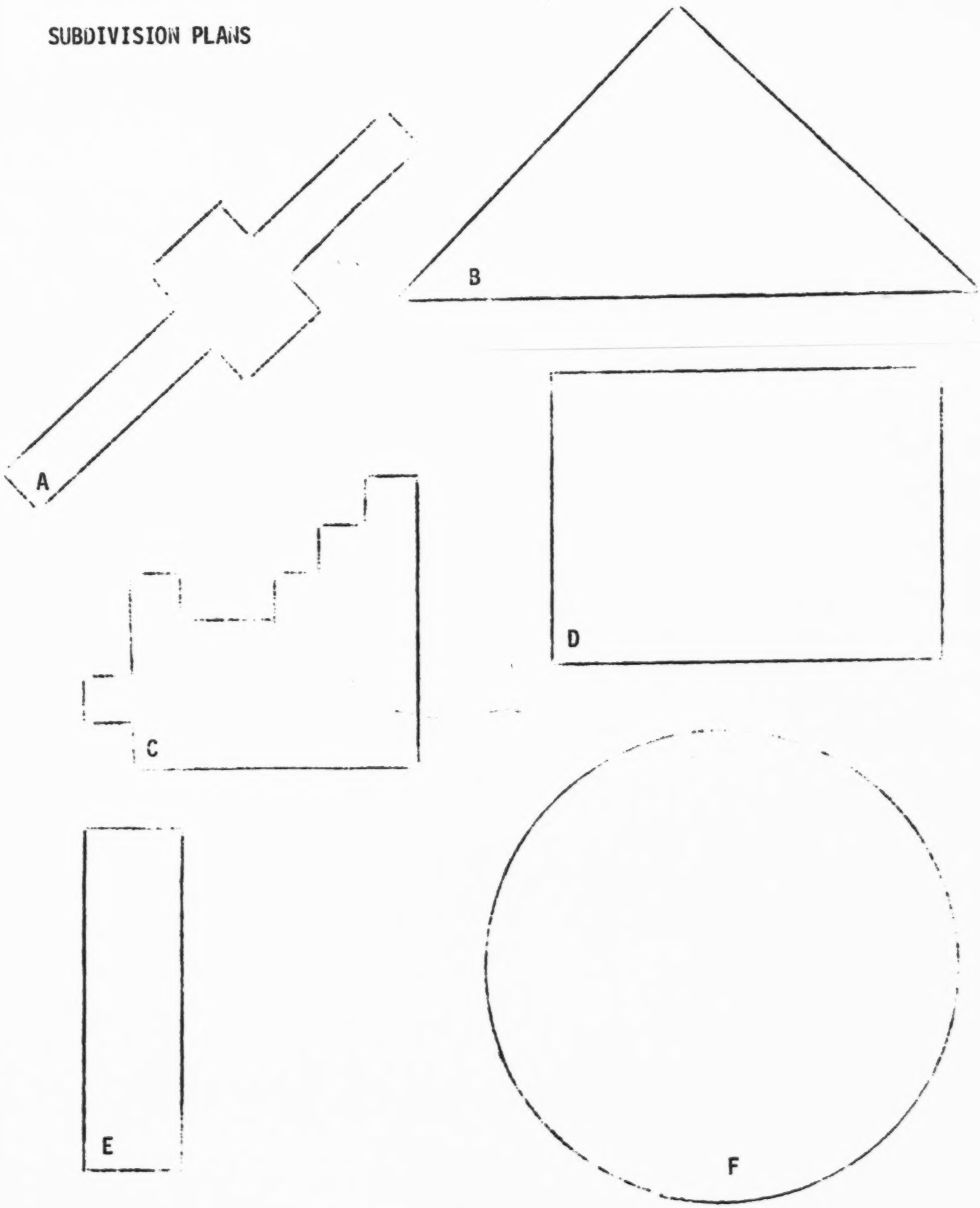
   _____

3. Attached are sketches of a leaf. Name two properties common to each.

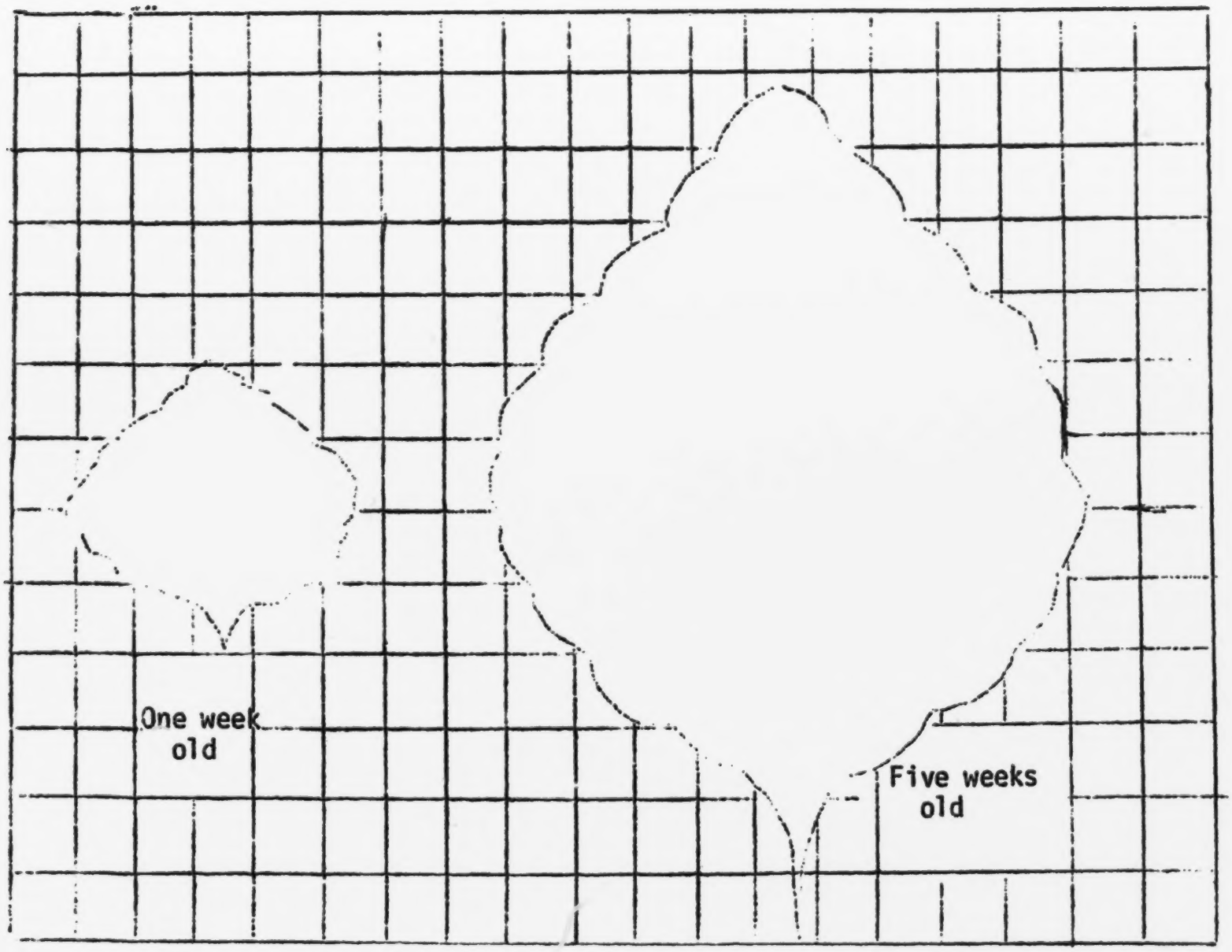
   _____

   _____

SUBDIVISION PLANS



Here are two diagrams of a leaf at two different ages: one week and five weeks.



STICKS, SPHERES, & SQUARES[3]

Task Objective

By the time you have completed this task you should be able to

> Describe objects (length, area, volume, mass, etc.) by comparing them quantitatively using either arbitrary units of comparison or standard units of comparison.

Task Focus

Petunias grown in a flower pot seem to differ from those grown in a garden plot.

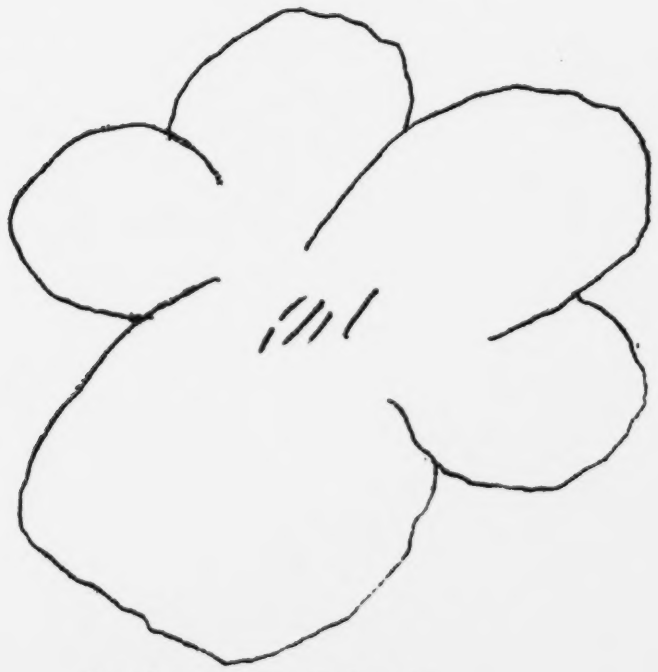
1. Describe 3 ways the drawings (below) of the petunias can be compared.

   a.
   b.
   c.

2. Describe the differences using the petunias grown in a pot.

3. Describe the differences using a standard unit of comparison.

Flower Pot Petunia



Garden Plot Petunia

For possible answers, see Discussion of Task Focus, page 5.

Task Activities

Using the A stick in your materials, how many sticks long is

the chalk tray? _____
the door height? _____
the table height? _____

Were these measures exactly as long as 2, 3, or 4 sticks?

If not, if they were more than 2 sticks but less than 3 sticks, was it closer to 2 or 3?

By custom, we round off to the number of stick lengths that is closest to the actual length of an object.

How many A sticks wide is the desk?

_____

This sheet of paper?

_____

What happens when you round off here?

_____

_____

_____

Try measuring the paper with the B stick. How many sticks long is it?

_____

What is the paper's width?

_____

How many B sticks long is your pencil?

_____

How many B sticks wide is your pencil?

_____

(What happens when you round off here?)

Use the C stick to describe how wide your pencil is.

_____

How many C sticks wide is your thumb?

_____

Look back at the B stick. Estimate how many C sticks long the B stick is.

_____

Measure it. Your results are _____.

Estimate here how many B sticks long the A stick is.

_____

Measure it. Your results are _____.

You may know the name of these sticks.

A stick = 10 B sticks = 100 C sticks
Meter = 10 Decimeters = 100 Centimeters

It may be of interest for you to note that the "fun" names for these sticks are:

A = Dollar stick = Meter
B = Dime stick = Decimeter
C = Penny stick = Centimeter

Measure your partner's height with the marked meter stick. Now measure his finger tip to finger tip width. How do they compare?

_____

Have your partner measure your height and finger tip width. What conclusions seem reasonable?

_____

_____

Take out the spheres in Packet C. Arrange or order these spheres by how heavy they feel to you. Describe the order.

Any problems?

What might you find helpful when the differences in how heavy objects feel is very small?

Using the scale, check your order of the spheres. Any changes?

How much more push on the scale does the heaviest sphere have than the lightest?

Describe how you found out.

How many paper clips have the same push on the scale as the lightest sphere?

The heaviest sphere?

How much more "clip push" does the heaviest sphere have than the lightest sphere?

What other units could be used instead of clips?

What is the standard unit used to compare the amount of stuff in objects?

Use the gram masses to describe the comparison of stuff in the spheres.

Now remove the blocks from Packet E. Order these blocks and describe your basis.

State the rule for determining the volume of a solid object like a block.

Use the ruler to compute the volume for the five blocks.

1.
2.
3.
4.
5.

NOTE: Use centimeters as your unit of measure.

Suppose you didn't have a ruler. Describe how you could use the graduated cylinder to describe the volume of the blocks. (Hint--would water help, especially with those blocks that fit inside the cylinder?)

Fill the cylinder to the 50 ml mark.

What does ml mean? _____

The smallest cube in Packet E had what volume when you measured it with the ruler?

When you measured that cube with the graduated cylinder, what volume does it have?

What is the relationship between a cubic centimeter (cc) and a milliliter (ml)?

What is the main idea of this set of tasks?

How does this relate to teaching science to children?

You may wish to read more on measuring (pages 102-111) and the metric system (pages 244-253) in the Commentary for Teachers.

You are now ready for the Competency Appraisal. Please have the instructor score this as soon as you finish.

Discussion of Task Focus

1. There are several kinds of comparisons such as

   -- longest line across
   -- shortest line across
   -- area of entire flower
   -- area of individual petals.

2. Such a comparison might be the plot petunias are twice as large as the pot petunias.

3. The pot petunia is 5 cm across and the plot petunia is 7 cm across.

COMPETENCY APPRAISAL

1. Attached are sketches of a leaf. Describe three ways the growing leaf can be compared.

_____

_____

_____

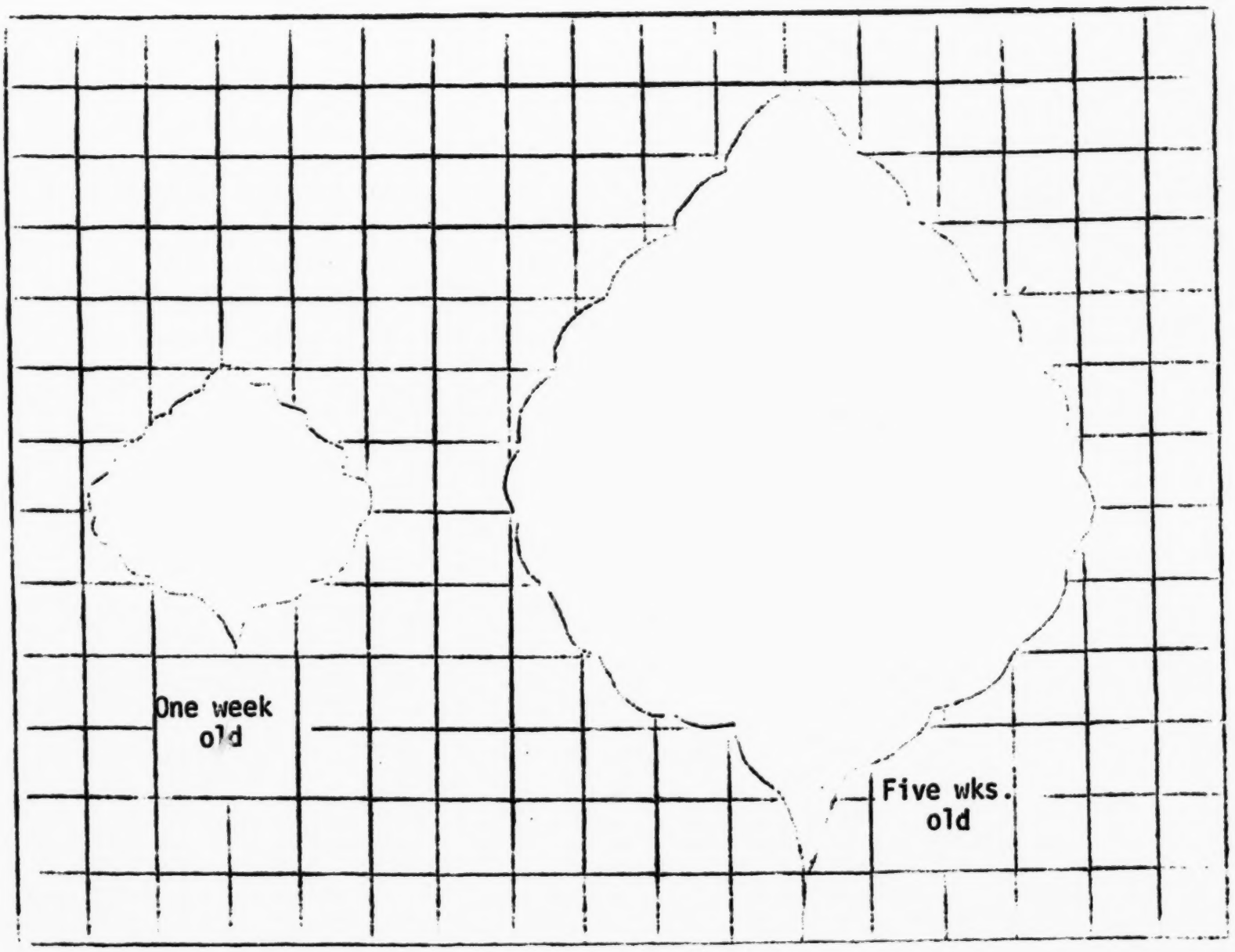
2. Describe the leaf at five weeks using the leaf at one week as a unit of comparison.

_____

3. Describe the leaf at one week old using a standard unit of comparison.

_____

Here are two diagrams of a leaf at two different ages: one week and five weeks.



ESTIMATION

Task Objective

When you complete this set of task activities you should be able to

DDescribe objects by making quantitative estimates of their dimensions.

Task Focus

Use no tools for measuring, please.

The line above is 8 cm in length.

Estimate the length of the following lines:

Which of these lines is closer to 5 cm in length?

Check your estimates with page 3.

Task Activities

We have been working with measuring various objects. At times you may not have a measuring unit available and need to estimate.

Complete CO #2 and then use the ruler to check your results. (Page 2)

You are now ready for the Competency Appraisal. Please have the instructor score it as soon as you finish.

1. Estimate the width of this paper in cm.

_____

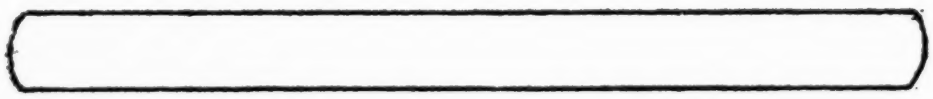
2. There are three types of film: 8 mm, 16 mm, and 35 mm. Mark these lines to show the width of each film.

8 mm _____

16 mm _____

35 mm _____

3. Advertisement is being made about the "silly millimeter" that is being added to cigarettes. Show how much longer this cylinder would be if a millimeter was added.



4. What is the length of your shoe in decimeters?

_____

5. A rock hit an auto windshield and the crack spread out in all directions from the point of impact about 2 cm from the center. Draw a circle the size of the cracked area of the windshield.

Discussion of Task Focus

1. The length of the three lines are:

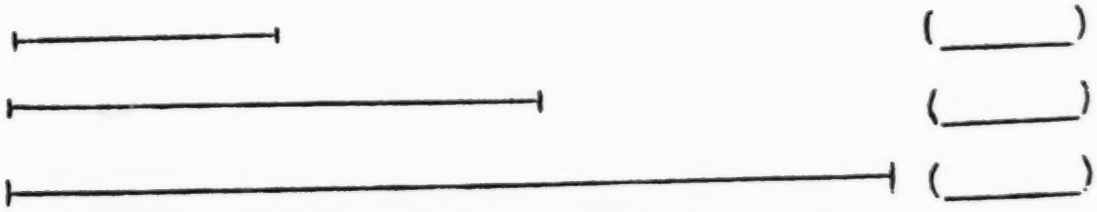
   2 cm
   8 cm
   12 cm

2. The middle line is 5 cm in length.

COMPETENCY APPRAISAL

Task 6: Use only your writing implement--no other tools.

The line above is 10 cm in length. Estimate the length of the following:

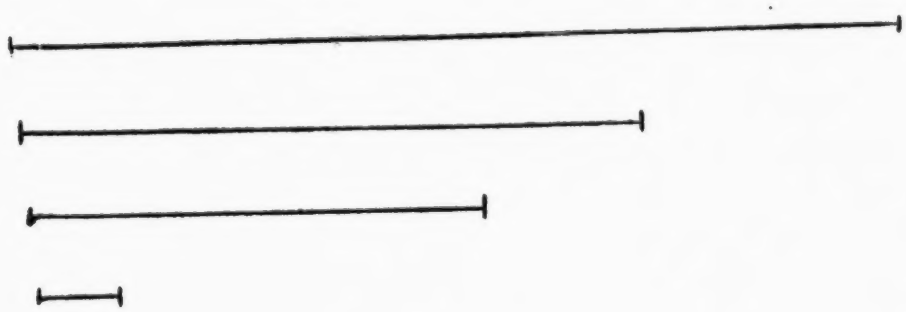


(_____)

(_____)

(_____)

Which of these lines is closest to 8 cm in length?
Draw a circle around it.



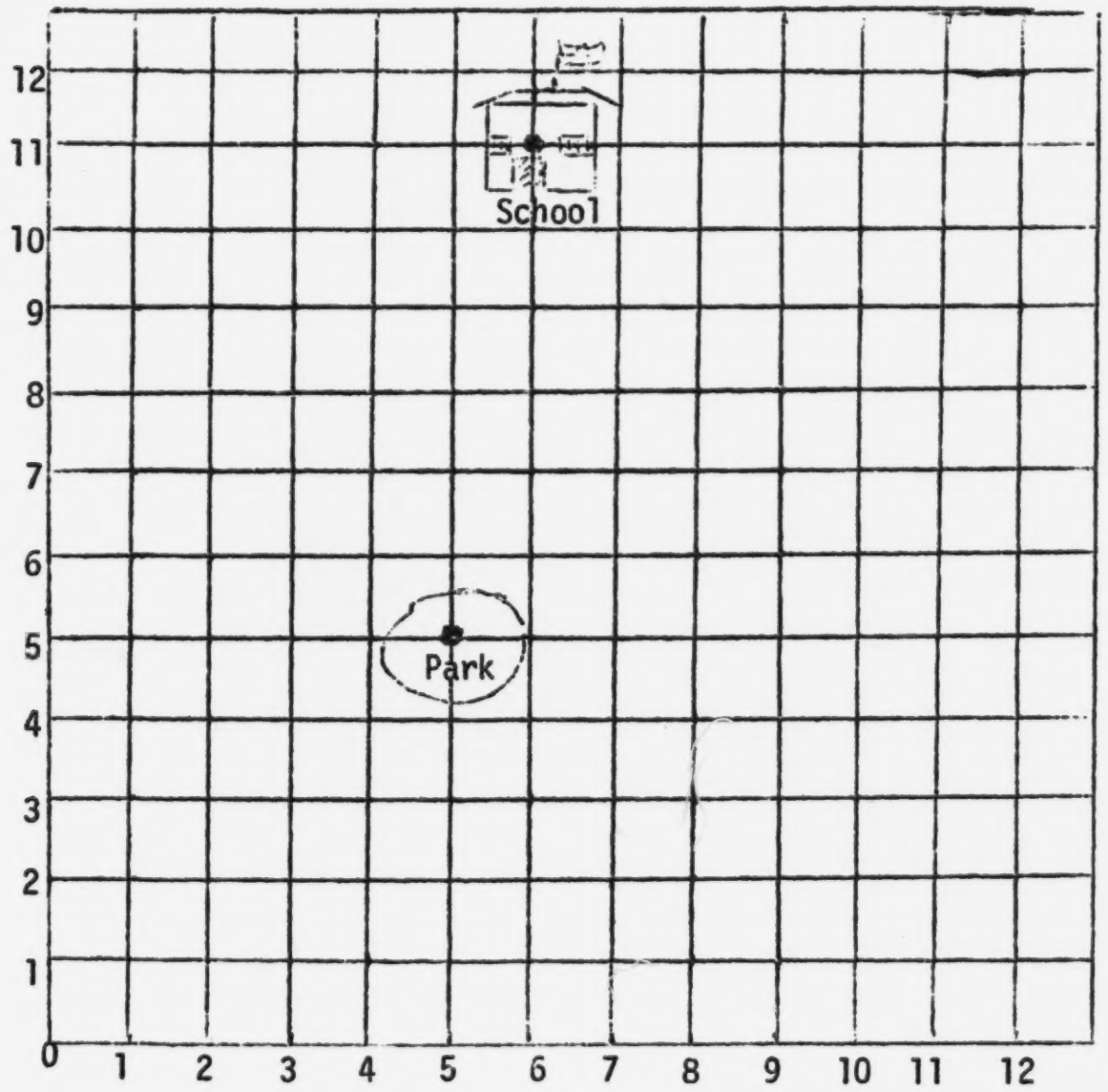
GRIDS

Task Objective

At the end of this task you should be able to

Describe the location of objects using a two-coordinate system.

Task Focus



Describe the location of

A. Park _____

B. School _____

See answers, page 2.

Task Activity

Place yourself with your back to your partner.

On the attached plain sheet of paper, place an X and then describe its location so your partner can place an X on his paper in a similar position. (You may wish to practice this several times.)

Now use the attached sheet of grid paper and place an X on one of the intersections, and then describe its position so your partner can also place his X in a similar position.

Continue to mark locations, but this time number the lines on the grid. Use these numbers to describe the intersections, the position of the axis.

There are some specific customs to use here.

1. The across axis is always the X axis.
2. The vertical axis is always the Y axis.
3. In expressing coordinate paris describe X first and then Y. (Note in the alphabet X comes before Y.)

If you wish to read more about coordinates and graphing, please see pages 112-134 in the Commentary for Teachers.

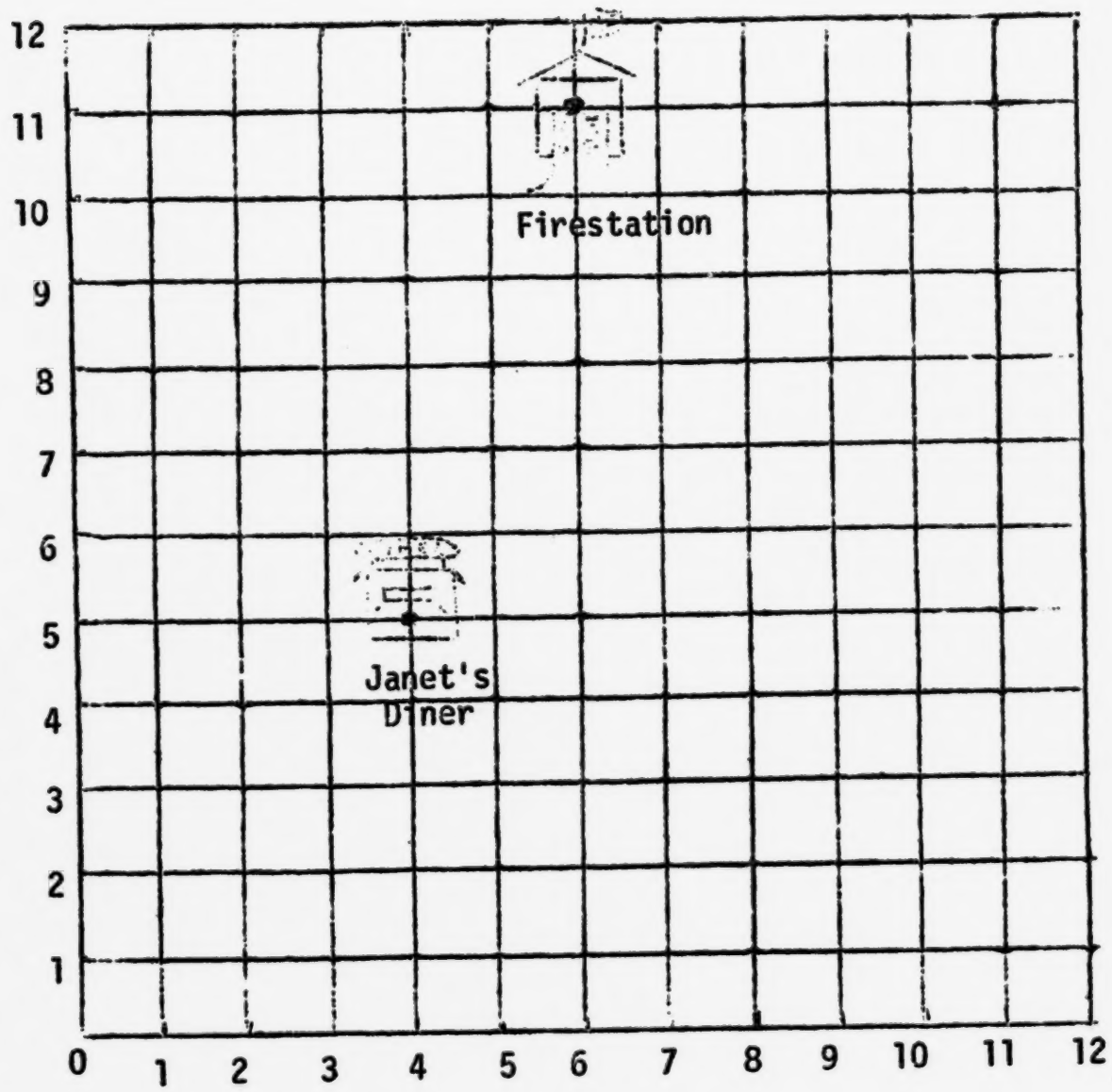
You are now ready for the Competency Appraisal. Please have the instructor score it as soon as you finish.

Discussion of Task Focus

The location of the park is 5 (on the X axis) and 5 (on the Y axis) or (5,5).

The location of the school is (6,11).

COMPETENCY APPRAISAL



Describe the location of

A. Janet's Diner _____

B. The Firestation _____

CARTOONS

Task Objective

At the end of this task you should be able to

Construct statements that are observations and inferences.

Task Focus

In the materials you will find a single concept film loop. Watch it one or two times and then list two observations and two inferences.

Observations:

1.

2.

Inferences:

1.

2.

At the end of this task you will find acceptable responses, (page 7.)

Task Activity

The distinction between observation and inference is essential to productive investigation in science. The cartoon figures may seem simple--but they will require careful thought. See pages 2, 4, 5, and 6.

Using the first set, circle the appropriate letter as to whether the statement is an observation or an inference. With your partner, check yours against his.

Continue with each of the sheets. For each sheet also identify the sense which is the source of information.

In the "cubes" task (Task 1) you defined observation. Restate your definition here.

_____

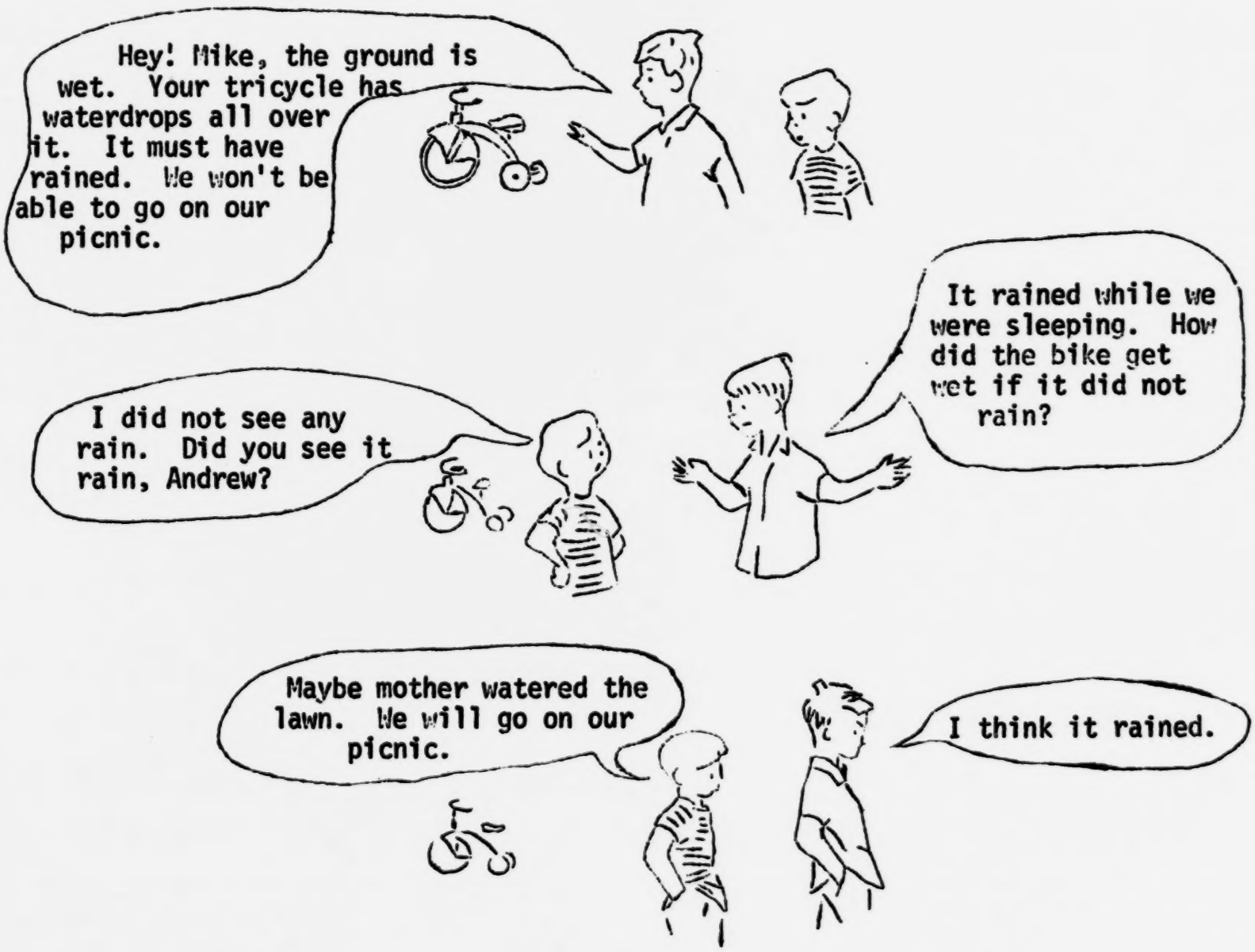
_____

_____

Now state your definition of inference._____

_____

_____


Hey! Mike, the ground is wet. Your tricycle has waterdrops all over it. It must have rained. We won't be able to go on our picnic.
It rained while we were sleeping. How did the bike get wet if it did not rain?
I did not see any rain. Did you see it rain, Andrew?
Maybe mother watered the lawn. We will go on our picnic.
I think it rained.

Which of the following statements are observations? Which are inferences? Circle) if you think the statement is an observation; circle I if you think it is an inference.

The ground is wet.	0	I
The tricycle has water drops on it.	0	I
It rained while we were sleeping.	0	I
Mother watered the lawn.	0	I

Which senses did Andrew and Mike use to make the observations?

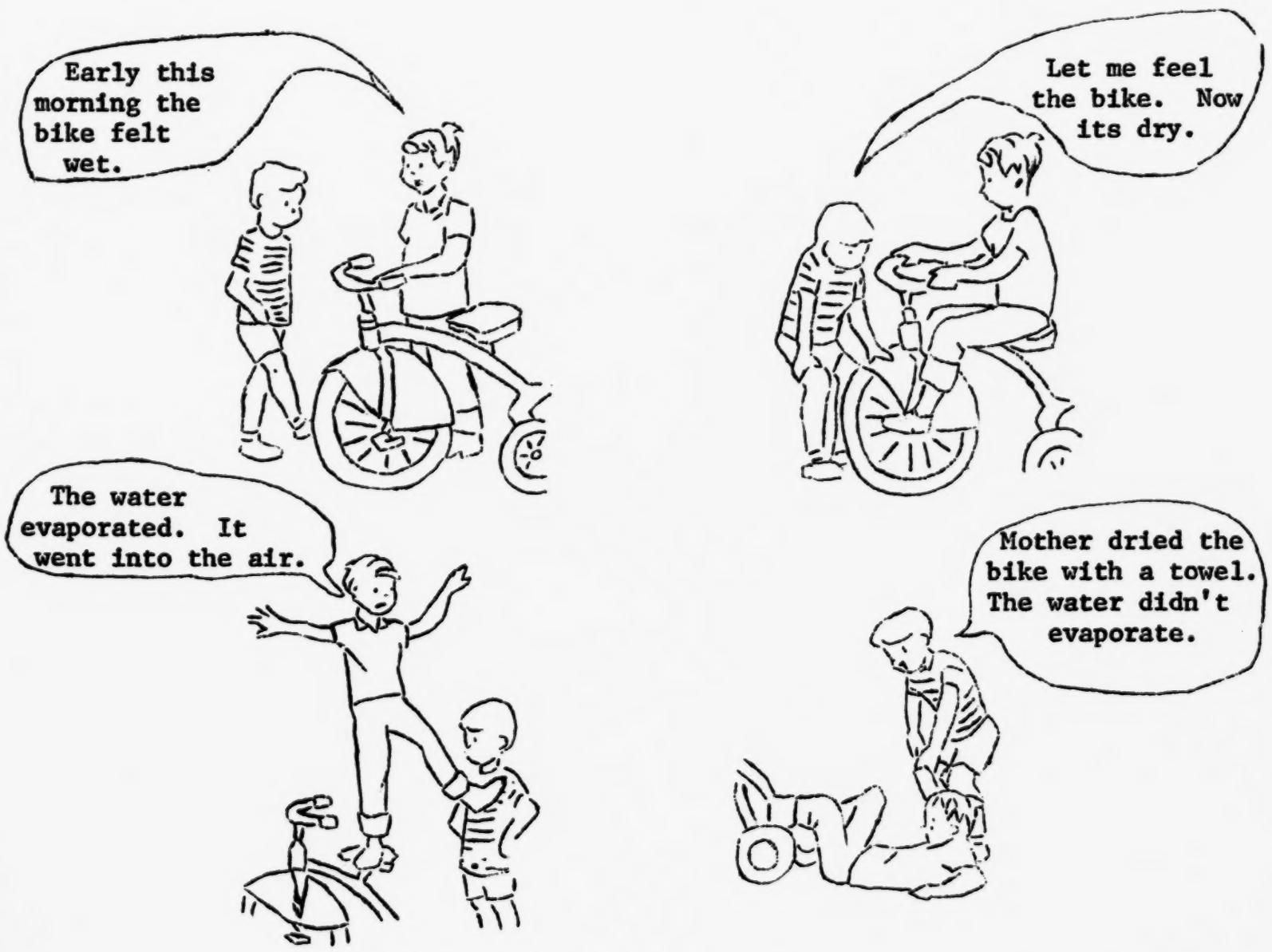
What would you do to find out which boy is right in the inference he made?

Which statements are observations? Which are inferences? Circle O if you think the statement is an <u>observation</u>; circle I if you think the statement is an <u>inference</u>.

The tricycle felt wet.	O	I
Now it is dry.	O	I
The water evaporated. It went into the air.	O	I
Mother dried the tricycle.	O	I

What kinds of observations were made? Circle the senses used:

Seeing, smelling, feeling, hearing, tasting.

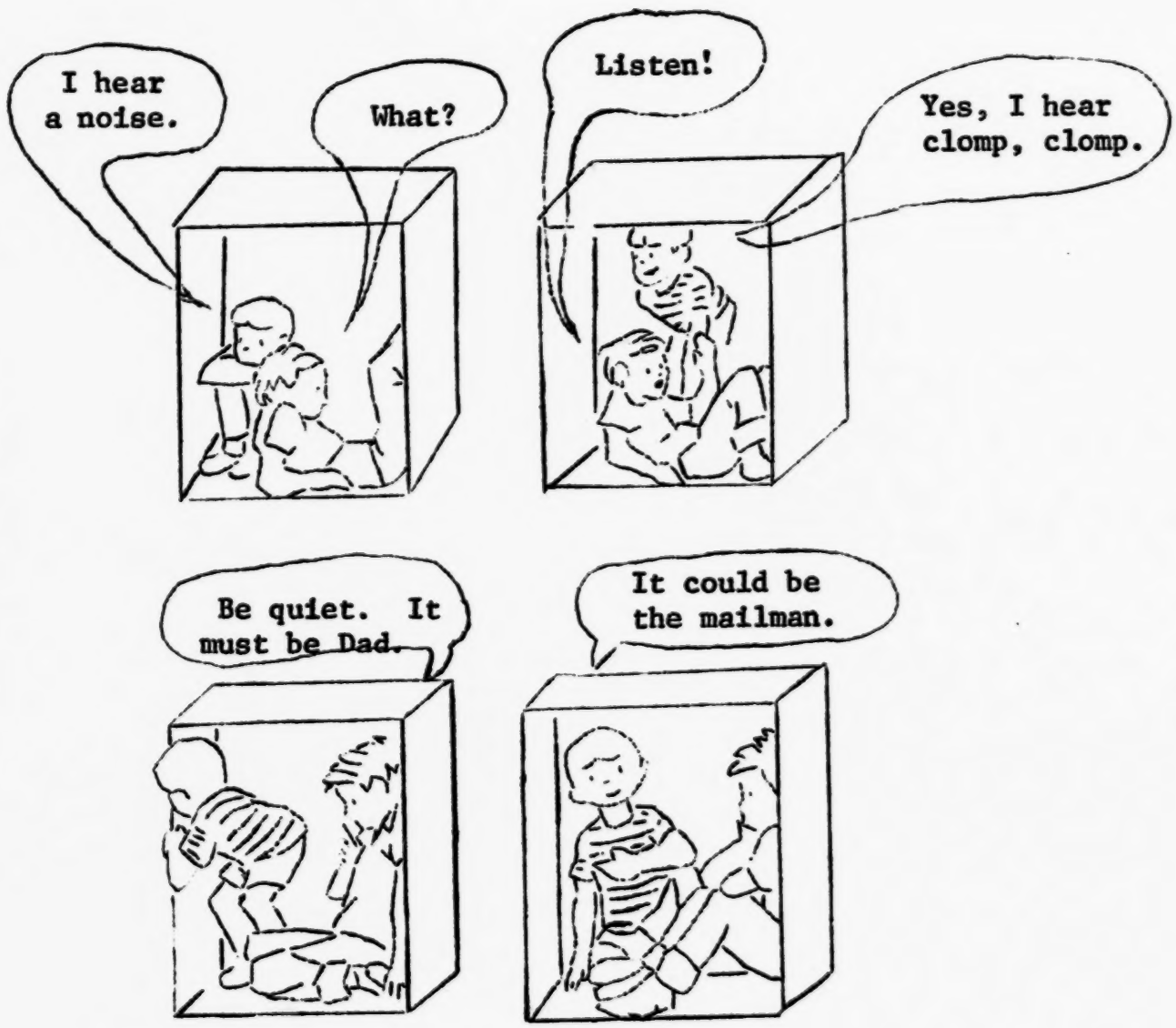

Early this morning the bike felt wet.
Let me feel the bike. Now its dry.
The water evaporated. It went into the air.
Mother dried the bike with a towel. The water didn't evaporate.

Circle O if you think the statement is an <u>observation</u>; circle I if you think it is an <u>inference</u>.

I hear a noise.	O	I
I hear clomp, clomp.	O	I
It must be Dad.	O	I
It could be the mailman.	O	I

What kinds of observations were made? Circle the senses used:

Seeing. Smelling. Feeling Hearing. Tasting

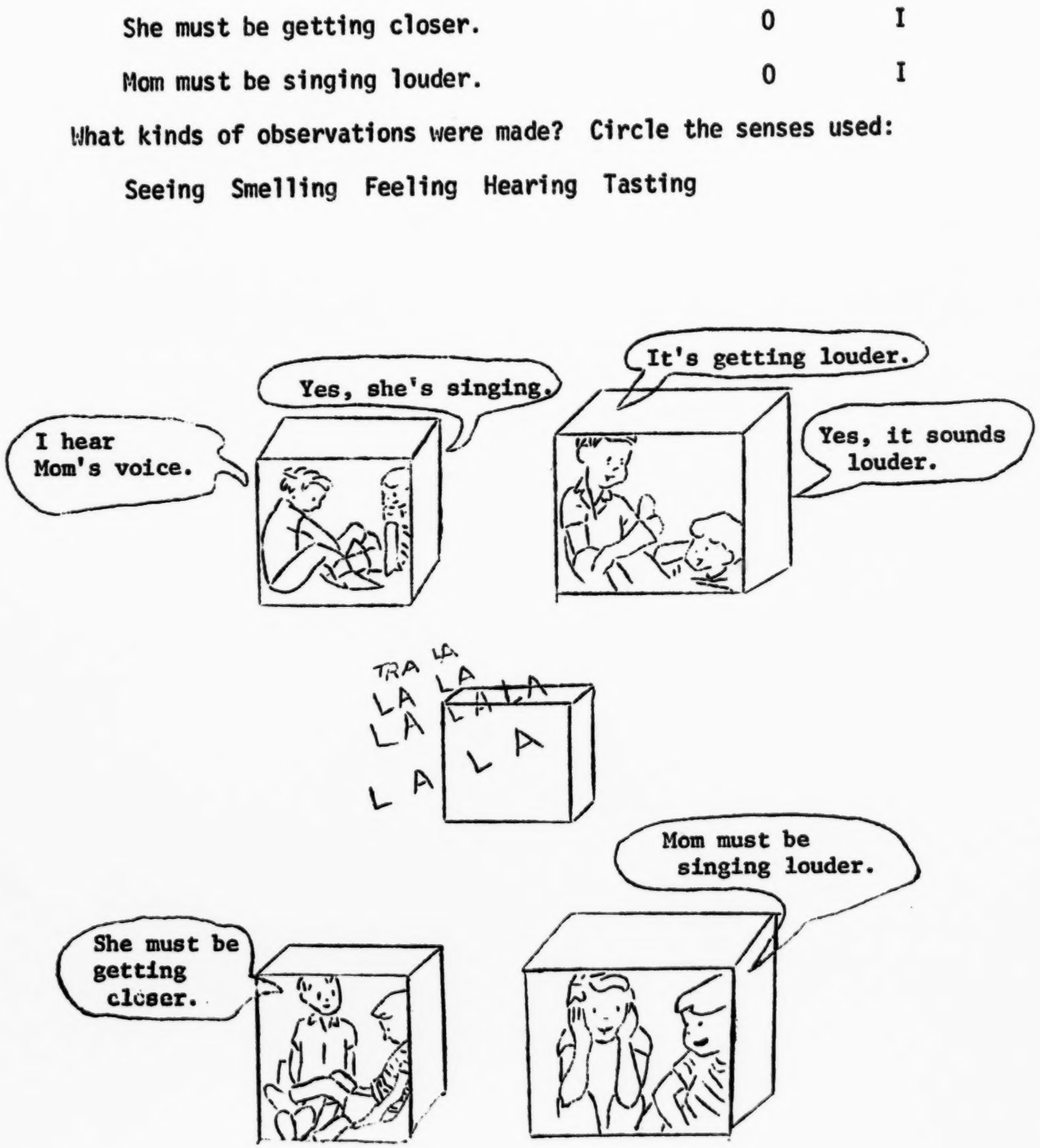


Circle O if you think the statement is an <u>observation</u>; circle I if you think it is an <u>inference</u>.

I hear Mom's voice.	O	I
Mom is singing.	O	I
It sounds louder.	O	I
She must be getting closer.	O	I
Mom must be singing louder.	O	I

What kinds of observations were made? Circle the senses used:

Seeing Smelling Feeling Hearing Tasting



In what ways is an observation similar to an inference?

In what ways is an observation different from an inference?

You may wish to think more about inferences and read page 141 of the Commentary for Teachers.

You are now ready for the Competency Appraisal. Please have the instructor score it as soon as you finish.

Discussion of Task Focus

Your observation should have included descriptions of the objects or events in the film.

Your inferences should be the explanation of why the event took place or interpretation of parts of the film which you could not directly observe or see.

COMPETENCY APPRAISAL

Based on what you have seen in the filmed episode; please construct 2 statements of observation;

1. _____

2. _____

Construct 2 statements of inference.

1. _____

2. _____

S & P BOXES

Task Objective

At the end of this task you should be able to

Construct alternative inferences from a set of observations and identify which observations support the inference.

Task Focus

When he returned from his vacation of two weeks, Mr. B. observed several things about his yard.

A. The grass was a brown color in many places.

B. The leaves of the grass appeared to be folded up.

C. There were large cracks in the soil.

Write three inferences that might explain Mr. B.'s observations.

1.

2.

3.

Give the letter of the observations upon which your inferences were based.

1.

2.

3.

See page 5 for possible answers.

Task Activities

Using the three boxes, name two things that you think could be in each of the three boxes.

Box A	Box B	Box C
1.	1.	1.
2.	2.	2.

For one of the things that you named in each of the boxes, list four observations that support that inference.

Inference	Observations
A. _____	1. 2. 3. 4.
B. _____	1. 2. 3. 4.
C. _____	1. 2. 3. 4.

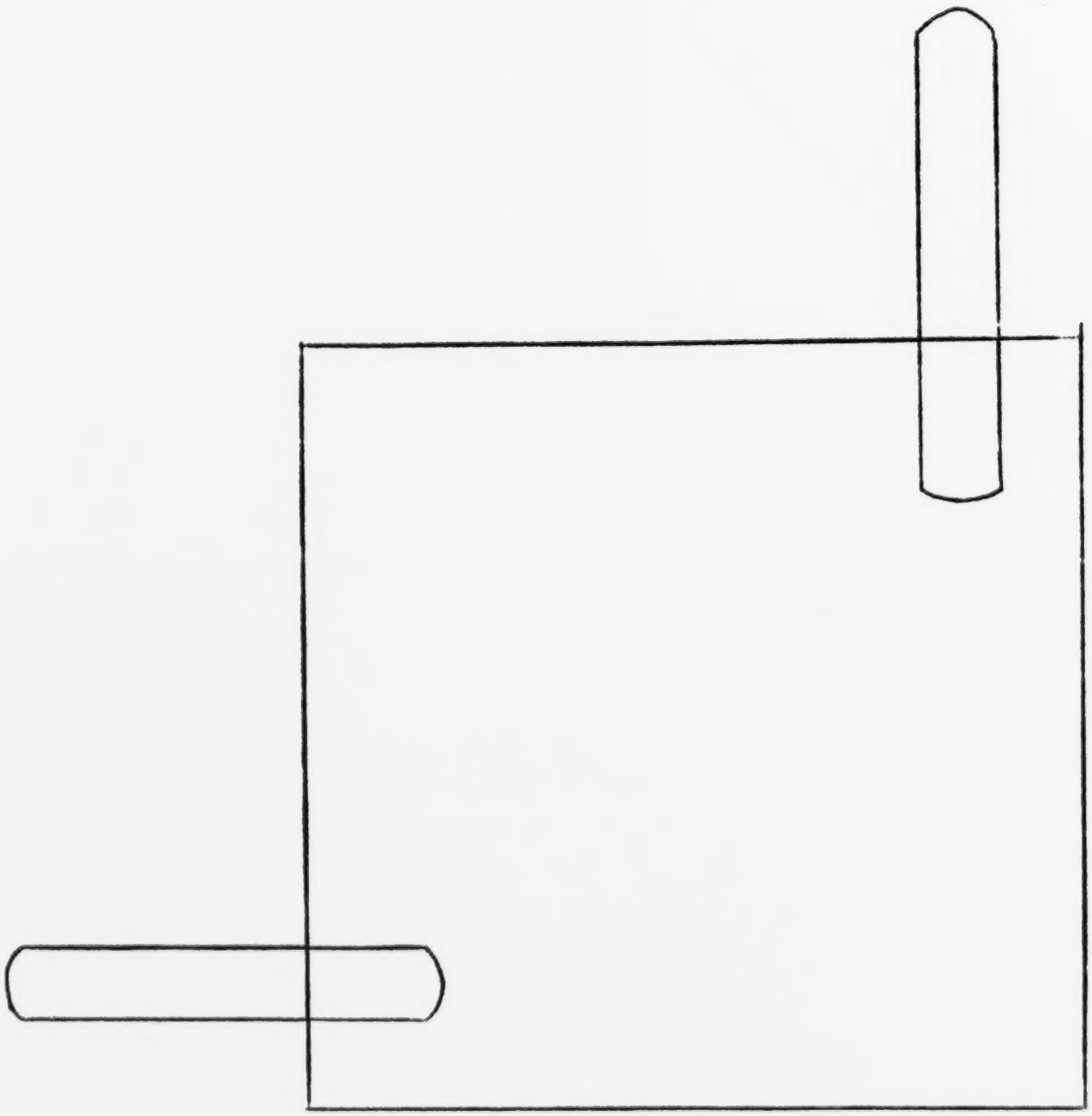
Now take out the two push rod boxes. You may examine the push rod box in any way you wish, EXCEPT you may <u>not</u> open it. On page 3 draw what you think it looks like inside the box.

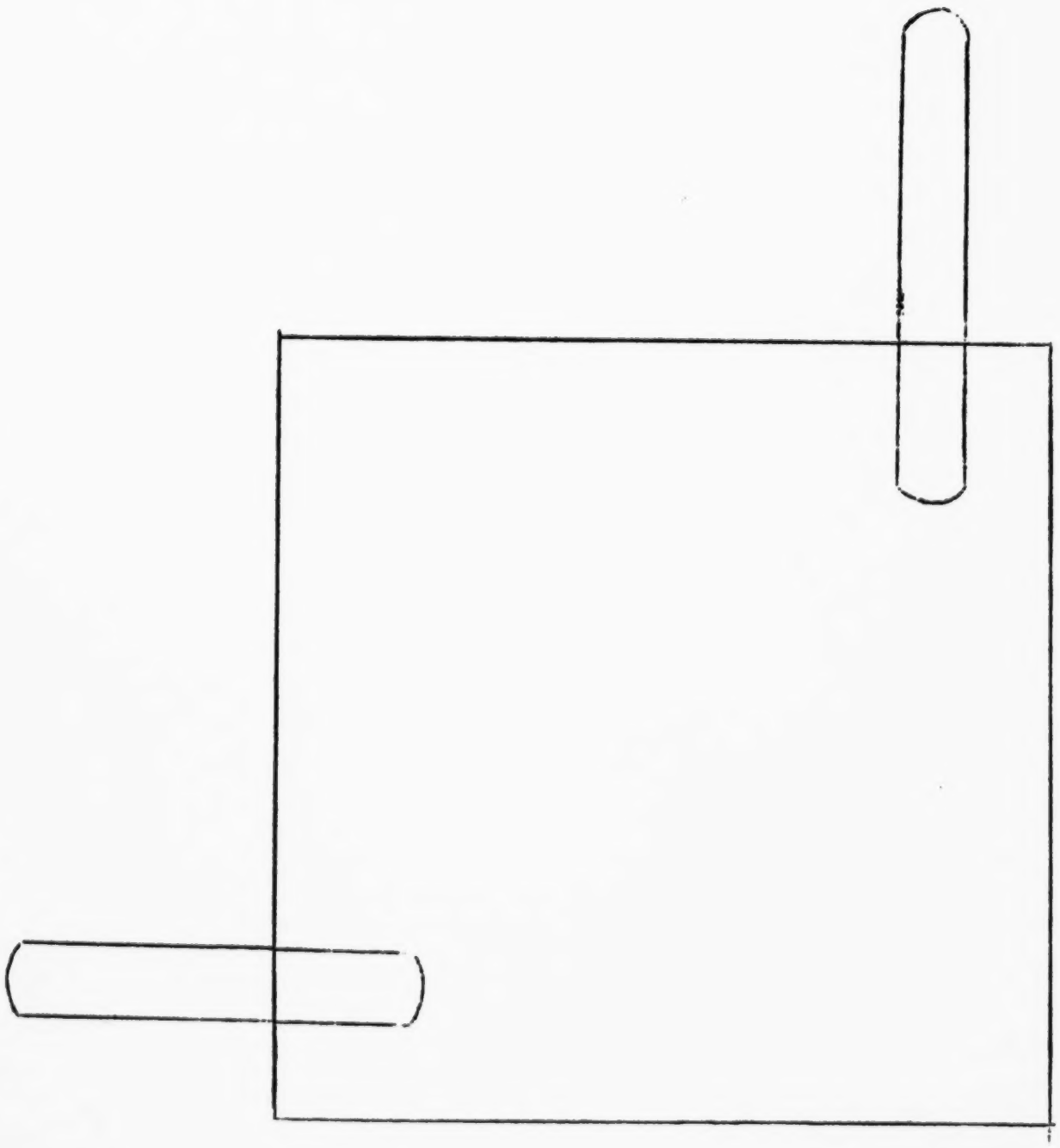
Exchange your box and diagram with your partner. With your partner's diagram, describe how <u>you</u> would test <u>his</u> inference.

Together decide what observations were made to support the diagrams.

What observations did you make that do not support a diagram for each box?

Based on your observations, construct a new diagram for each of the two boxes. (Use page 4)





In what way were the two box tasks similar?

How is inferring related to science?

You may wish to read more about inferring in the Teacher's Commentary on pages 141-160.

You are now ready for the Competency Appraisal. Please have the instructor score it as soon as you finish.

Discussion of Task Focus

Inference 1. The neighbor hadn't watered the yard. (B,C)

Inference 2. The weather had been hot and very dry during the past two weeks. (A, C)

Inference 3. A disease had invaded his yard. (A, B)

You may have had others--but, they should be explanations or reasons for the observations.

COMPETENCY APPRAISAL

In a room there were two jars. I observed the following:

1. The jar at the front of the room has a higher water level than the jar on the window sill.

2. There was a puddle of water on the window sill near the jar.

3. There was a trail of wet spots on the floor, leading from the door to the jar at the front of the room.

4. Earlier in the day, the window was open near the jar on the window sill.

Based on the observations listed above, write three inferences that explain or account for the different levels of water in the two jars.

Inference A_____

_____

Which 2 observations support your inference A: 1 2 3 4 (Circle)

Inference B_____

_____

Which 2 observations support inference B: 1 2 3 4 (Circle)

Inference C_____

_____

Which 2 observations support inference C: 1 2 3 4 (Circle)

BOTTLED WATER

Task Objective

At the end of this set of tasks you should be able to

Demonstrate a test for an inference by describing what additional observations are needed.

Task Focus

Describe how you would test each of your inferences from the Task Focus, Task # 11 (Mr. B's yard).

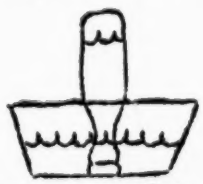
See page 3 for Discussion of Task Focus.

Task Activities

You have a set of objects provided for you.

1. Name the objects in your system.

2. Now fill the plastic container 2/3 full with water and fill the pop bottle with water. Invert it in the plastic container of water.



Describe and demonstrate how you could remove the water from the bottle, but note three rules apply:

a. The bottle may not be taken out of the water.
b. You may not drink the water.
c. You may not take any water away.

3. List two alternative inferences as to what happened to the water and two observations to support each inference.

	Inferences	Observations
A.		1.
		2.
B.		1.
		2.

4. Describe how you would test inference A and then demonstrate your test.

5. What were the results of your test in #4?

6. If you were to design a new test for the task in # 4, what would you do?

In what way is an inference different from a prediction?

In what way is an inference different from an observation?

In what way is an inference different from a guess?

In what way does the testing of an inference and the testing of a prediction differ?

You are now ready for the Competency Appraisal. Please have the instructor score this as soon as you are finished.

Discussion of Task Focus

More than one observation can be used to support an inference. Here you should have checked those observations that make your inference seem reasonable.

Your test should include making more observations and changing the specific observations that supported the inference.

COMPETENCY APPRAISAL

Describe additional observations you might make that would test Inference A from your Competency Appraisal for Task # 11 (Jars of water).

_____

_____

_____

What is your reason?_____

_____

BOUNCING BALLS

Task Objective

At the end of this set of activities you should be able to

1. Construct a prediction from a point graph by applying the rules of extrapolation and interpolation.
2. Demonstrate a test of a prediction.
3. Order a set of predictions or inferences based on a level of confidence.

Task Focus

A group of students were observing the growth of gerbils. They measured the weight of these gerbils for several days. Here are their results:

Age of Gerbils (days)	Weight of Gerbils (grams)
2	11
4	14
6	18
8	22
10	23
12	24

A. Construct a point graph of this data. Use Page 2.

B. The manipulated variable in this activity was _____.

C. The responding variable in this activity was _____.

D. What was the weight of the gerbils at

13 days? _____
26 days? _____
7 days? _____
1/2 day? _____
birth? _____

E. Describe how you would find out if one of your predictions in "D" was correct.

F. You made five predictions in "D". List them in order of greatest confidence you have that they are correct.

Most Confident Least Confident

_____ _____ _____ _____ _____

Task Activities

Taking the balls that are provided for you in the kit,

1. Determine the bounce height of each ball when dropped from lines 2, 4, and 6. (Please show your work.)

2. Construct a graph of your results.

3. Using your graph, what would you predict the bounce height of a

golf ball, from line 5 _____
ping pong ball, from line 3 _____
pink rubber ball, from line 1 _____
golf ball, from line 18 _____

With which predictions do you feel most confident? _____

Why?

Which predictions were within your range of observation?

Which predictions were outside your range of observation?

A prediction <u>within</u> your range of observation is called an <u>inter</u>polation.

A prediction <u>outside</u> your range of observation is called an <u>extra</u>polation.

Describe the procedure by which you test a prediction.

What is the difference between a prediction and an observation?

What is the difference between a prediction and a guess?

What is the relationship between predicting and science?

You may wish to read more about predicting on pages 141-160 in the <u>Commentary for Teachers</u>.

You are now ready for the Competency Appraisal. Please have the instructor score this as soon as you finish.

Discussion of Task Focus

A. You may recall thatyyou need three things in your graph:

1. label of X axis - days since birth
2. label of Y axis - weight in grams
3. title of graph - gerbils weight change

B. The manipulated variable is the one that you choose, hence the days the gerbils were weighed.

C. The responding variable is the one that you measured, hence the weight.

D. 24 ½ grams--since it had been increasing at ½ grams per day for the last 3 days.
31 grams--halfway between 6 and 8 days.
20 grams
9½ grams--halfway between birth and 2 days
8 grams--

E. You would need to be able to measure the weight of the gerbil on the day specified.

F. 7 days 13 days ½ day 26 days birth

You have more confidence for predictions within your range of observations than for those outside the range of observations.

You also have more confidence in those predictions that are closer to known observations.

COMPETENCY APPRAISAL

Another child comes to you and says he has really been acting like a scientist. He has been measuring the water height all day (when you weren't looking). His results:

Time	Water Height of Jar on Window Sill
9:15 A.M. (You went to the Principal's office)	19 cm
10:10 A.M. (P.E. time)	18 cm
11:45 A.M. (Lunch time)	16 cm
1:10 P.M. (You were still in the teacher's lounge)	4 cm
2:15 P.M. (Music time)	1 cm

A. Construct a point graph of his data.

B. The manipulative variable in this activity was _____.

C. The responding variable in this activity was _____.

D. What was the water height in the jar in the window sill at:

9:30 A.M. _____
10:30 A.M. _____
11:30 A.M. _____
12:30 P.M. _____
8:30 A.M. _____
3:30 P.M. _____

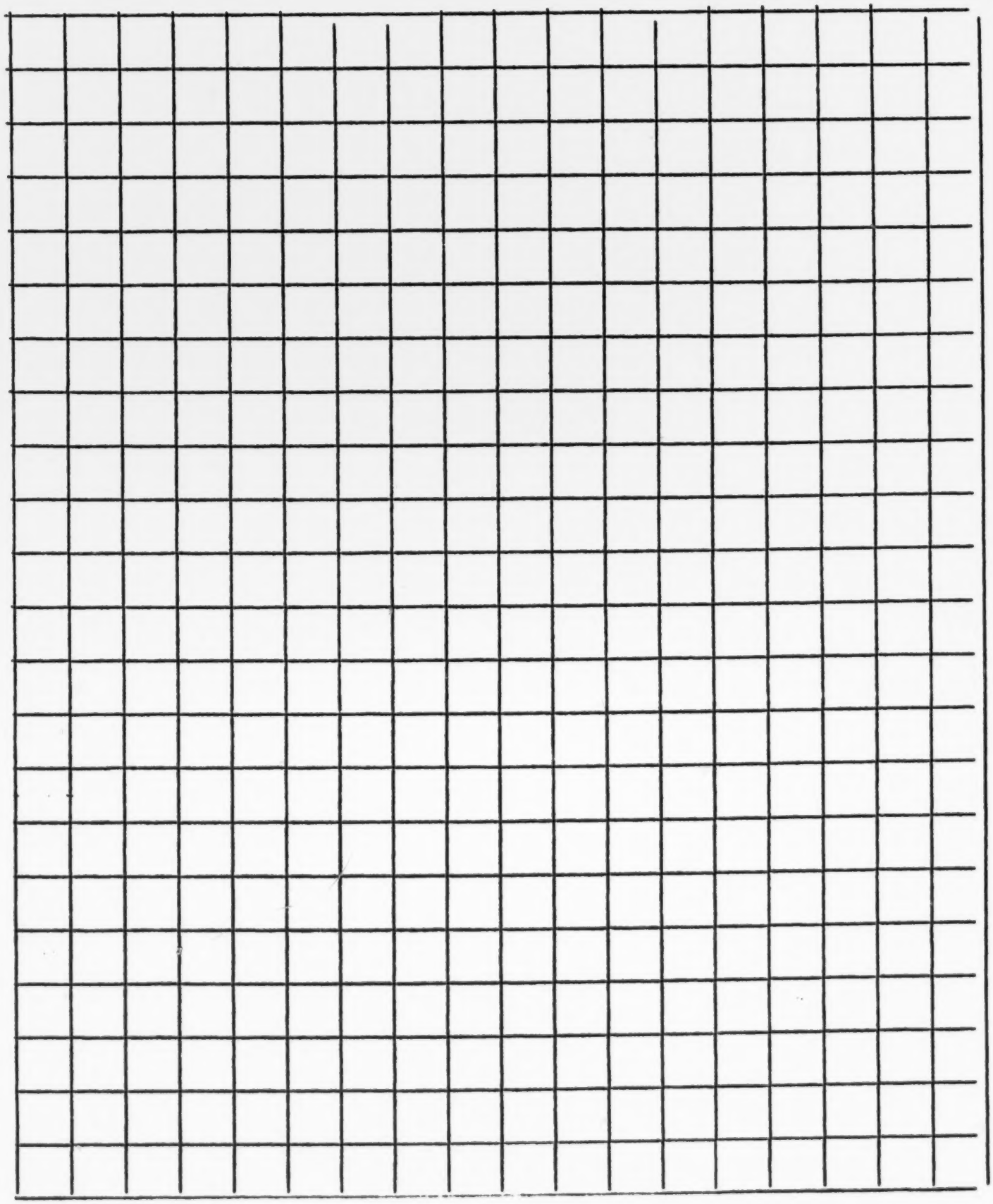
Describe how you would test your predictions.:

_____

_____

You made six predictions. Order them in terms of greatest confidence you have that they are correct.

Greatest Confidence					Least Confidence
_____	_____	_____	_____	_____	_____



ARROWS

Task Objective

At the end of this task you should be able to

Construct vector diagrams to describe such vector quantities as displacement, velocity, or force.

Task Focus

Two race car drivers were describing their success. They appeared to have some difficulty communicating their results, however. George drove six miles west and Gene drove two miles east. Both started from the same point and both drove the same time. Draw arrows to describe their velocity and displacement.

Displacement Arrows

Velocity Arrows

The next day's practice was over the same course. George drove it in six minutes and Gene drove it in two minutes. Draw arrows to describe their displacement and velocity of this day.

Displacement Arrows

Velocity Arrows

See page 6 for acceptable responses.

Task Activities

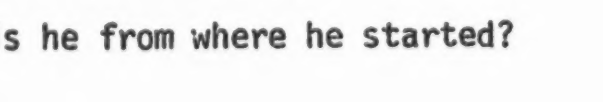
On page 3, mark the position of (0,1), (2,5), (5,5), and (6,1). Place one of the washers in each of these locations.

Now move the washers from

(0,1) ⟶ (6,3)
(2,5) ⟶ (3,0)
(5,5) ⟶ (4,0)
(6,1) ⟶ (4,4)

You may wish to practice several of these pairs and movings.

Place one of the cars at (0,1). Now do what this picture tells you:



Practice giving direction to your partner in moving the car to different locations.

Note the use of the arrow.

1. What does the head of the arrow tell you?

2. What does the line of the arrow tell you?

3. What do the number pairs tell you?

Draw an arrow that will picture this event: A garden spider crawled from (5,2) on the grid to (1,2).

What information does the arrow tell you?

Suppose the spider then crawled from (1,4) and on to (5,5). Draw arrows to picture this event.

What is the total distance he has crawled?

How far is he from where he started?

How far you are from where you started is called <u>displacement</u>.

In what way is displacement different from distance?

Suppose the spider travels from (1,3) to (3,1) to (6,3).

What was his distance traveled?

What was his displacement?

Use the two cars and move them the same distance. What will their displacement arrows look like?

Now make one car move about twice as fast as the other, but the same distance. What will their displacement arrows look like?

You may wish to communicate more than displacement with arrows. Suppose you want the length of the line to describe speed. How would the arrows now look?

NOTE: In both displacement arrows and velocity arrows, the head of the arrow tells <u>what direction</u>. The length of the arrow tells you <u>how far from the beginning point</u> (if it is a displacement arrow) and <u>how fast</u> (if it is a velocity arrow).

If you wish more help on displacement and velocity, please see the instructor.

Take out the two pieces of paper. Wad one into a ball and keep the other one flat. Hold them above you ahead and release them at the same time.

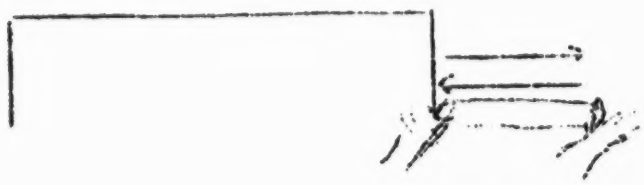
Draw displacement arrows for this event.

Now draw velocity arrows for this event.

Take out the two rubber bands and hook your thumbs in each end of a band. Hold your left thumb steady on the table and move your right thumb to the right. Now hold it. Tell your partner what is happening.

Use arrows to describe what is happening.

Here are two arrows to describe what happened.

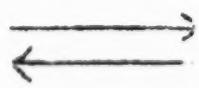


What do you think they are describing?

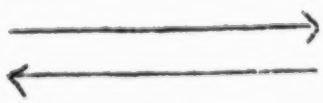
What does the head of the arrow tell you?

What does the line tell you?

Do this with a rubber band.



Now with a rubber band do this.



You felt the pull of the rubber band against your thumb. The rubber band also had the pull of your thumb against it. These pulls are always in pairs. Are the pairs always equal?

When are they equal?

When are they not equal?

Draw arrows to show the pulls or forces necessary to flip a band across a room.

Draw arrows to show the forces on the band when it stops.

You may wish to read more on forces and vectors in the Commentary for Teachers on page 262 (Velocity and Acceleration) and page 265 (Vectors).

You are now ready for the Competency Appraisal. Please have the instructor score it as soon as you finish.

Discussion of Task Focus

Since a displacement arrow pictures the total distance from a starting point and its direction, your arrow should look like:

Velocity reflects distance/time and the direction. The time was not given, but you know that they both traveled the same time, so let's say it was six minutes. George's velocity was 6 m/6 min. or 1 m/min west and Gene's velocity was 2 m/6 min. or 1/3 m/min east. So,

In the second race, the displacement will be the same as the first. The velocity, however, will change for now George did it in 6 m/6 min or 1 m/min and Gene has speeded up to 2 m/2 min. or 1 m/min. so that their arrows will be,

COMPETENCY APPRAISAL

Two jogging enthusiasts were describing their success. They appeared to have some difficulty communicating their results, however. Captain A jogged 8 units west and Major B jogged 2 units east. They both started from the same point and were jogging at the same time. Draw arrows to describe their velocity and displacement.

Displacement
Arrows

Velocity
Arrows

The next day's practice was a repeat over the same course. Captain A ran it in 8 minutes and Major B ran it in 2 minutes. Draw arrows to describe displacement and velocity of this day.

Displacement
Arrows

Velocity
Arrows

RATES OF CHANGE

Task Objective

By the end of this task you should be able to

Describe an object or event in terms of the rate of change of a property.

Task Focus

An egg embryo shows marked changes during days 5 to 7 of its incubation period.

Day 5

Day 7

Describe observable changes in the development of the embryo portion of the egg from day 5 to day 7.

Compute the rate of change for two properties of this embryo.

State the rule for computing the rate of change for a property of an object.

See page 3 for acceptable answers.

Task Activities

For Event A, light a candle and observe it until it goes out.

For Event B, inflate a balloon.

For Event C, place two or three drops of alcohol in your hand and observe it until it disappears.

List those things about these events which you think are important to describe.

Event A:

Event B:

Event C:

Did you describe the length of the time of the event? The size of the objects or any measurements of the objects?

For each event, identify two properties of objects which changed.

Event	Object	Properties which Changed
A	Candle	1.
		2.
B	Balloon	1.
		2.
C	Alcohol	1.
		2.

Now determine the rate of change for each of these six properties:

Event	Property which Changed	Rate of Change
A	1.	1.
	2.	2.
B	1.	1.
	2.	2.
C	1.	1.
	2.	2.

State a rule for rate of change.

You may wish to read more about the Rate of Change in the Commentary for Teachers on pages 40-58, 244.

You are now ready for the Competency Appraisal. When you have completed this, please take it to the instructor to be scored.

Discussion of Task Focus

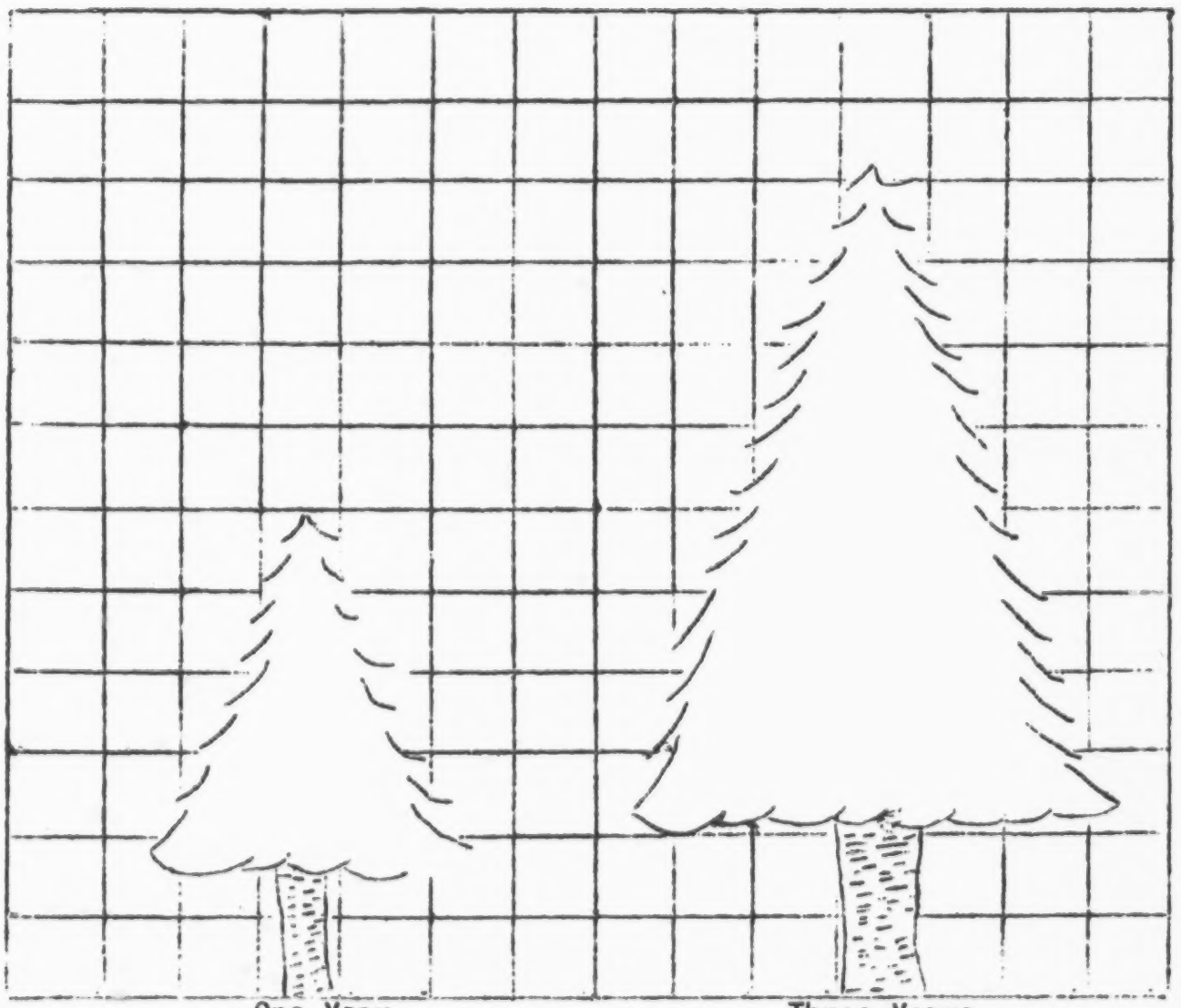
The embryo changes in length, width, area, and volume.

To compute the rate of change, you would take the length on day 7 minus the length on day 5 divided by two days. Similar for width or area.

Rule: Difference in property/divided by time.

COMPETENCY APPRAISAL

Here are two diagrams of a fir tree at two different ages: one year and three years.



One Year Three Years

Describe the observable changes of the diagram of the tree from one year of age to three years of age.

_____

Compute the rate of change for two properties of the tree:

_____

_____

State the rule for computing the rate of change of a property of an object.

_____

FRAMES OF REFERENCE

Task Objective

At the end of this task you should be able to

State and apply a rule for finding the resultant.

Task Focus

Janice has been practicing her jogging on a moving belt machine. The belt moves east from the starting switch at 3 meters/minute.

a. What is Janice's velocity relative to the starting switch if she jogs east at 1 m/min?

Describe how you could find out using arrows.

b. What is Janice's velocity relative to the starting switch if she jogs west at 3 m/min?

Describe how you could find out using arrows.

c. What is Janice's volocity relative to the starting switch if she jogs west at 2 m/min?

Describe how you could find out using arrows.

See page 4 for acceptable responses.

Task Activity

Place the chart paper on the wall and hang the string and chalk so it can swing freely in front of the chart paper.

Swing the chalk from one side to the other and catch it when it is about the same height on the opposite side from where you released it.

Draw a displacement arrow for the chalk.

Now let the chalk make a full swing and return. Draw a displacement arrow for the chalk.

In what way are the two arrows similar?

In what way are the two arrows different?

Now let the chalk swing from about 9:00 o'clock to 6:00 o'clock. Draw a displacement arrow.

Now move the chalk from 6:00 o'clock to 3:00 c'clock. Draw a second displacement arrow.

Now draw a displacement arrow for the combination of the two trips.

Which of your first arrows is more like this one?

State a rule about how you can "add" displacement arrows.

Your rule should have included the idea that you take the first displacement arrow and draw the next displacement arrow from the head of the first one. The resultant arrow is found by drawing a displacement arrow from the point of origin to the head of the last displacement arrow.

Mark a line two meters long on the floor. Have your partner practice walking that line until he can do it in two seconds.

Now hand your partner a pencil and have him put it in his pocket. Have him repeat the walking on the line in two seconds.

What is your partner's speed?

What is the speed of the pencil?

(You may wish to think about your partner's speed and the pencil's speed relative to the room. Thus, relative to your partner, the pencil did not move or did it?)

In the room you will find displayed a transparency of a diagram of a boat and a lighthouse.

Consider the ship and its three passengers. The ship's velocity is 4 m/second due east. Passenger A is a track coach standing motionless on the deck. B and C are his charges whom he has ordered to run about the the deck. Each is moving at 5 m/second with respect to the ship. B is headed east. Using 1 cm = 1 m/second, draw arrows to show B's velocity relative to the lighthouse.

What is B's velocity relative to the lighthouse?

What rule did you use to help you find the resultant velocity?

Now let's consider passenger C. He is moving 5 m/sec. westward. Draw arrows and find his velocity relative to the lighthouse.

State the rule by which resultant velocity is found.

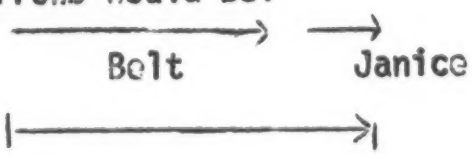
We have been describing relative velocity as we have described passengers B and C's velocity. What do you think is meant by the term "relative motion?"

You may wish to read more about velocity in the Commentary for Teachers on pages 262 and 265.

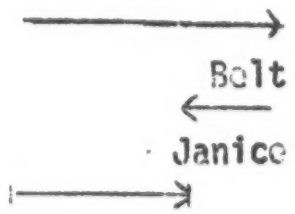
You are now ready for the Competency Appraisal. Please take it to the instructor to be scored when you have finished.

Discussion of Task Focus

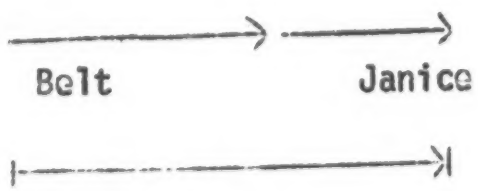
A. Relative to the starting switch, Janice would be moving 4 meters/minute east. Arrows would be:



B. Relative to the starting switch, Janice would be moving 2 meters/minute east. Arrows would be:



C. Relative to the starting switch, Janice would be moving 5 meters/minute. Arrows would be:



COMPETENCY APPRAISAL

A "moving sidewalk" has recently been installed in an airport. It moves west at 2 meters/minute. Several children were having fun walking on the moving sidewalk.

A. What is the boy's velocity, relative to the gate at the beginning of the moving sidewalk, if he walks west at 10 m/minute?

Answer _____

Describe how you could find out using arrows:

B. What is the boy's velocity relative to the west end of the moving sidewalk if he walks east at 2 m/minute?

Answer _____

Describe how you could find out using arrows:

C. What is the boy's velocity relative to the west end of the moving sidewalk if he walks east at 4 m/minute?

Answer _____

Describe how you could find out using arrows:

CANDLES AND WATER

Task Objective

At the end of this task you should be able to

1. Given a set of data and a set of statements about that data, distinguish between those statements of fact and those of interpretation.

2. Construct a systematic analysis of an event when given a set of data about that event.

Task Focus

In this chart, the results of baking two cakes in ovens at 350° and 450° are given.

Time after Putting Cake in Oven (minutes)	Height of Cake from Base of Pan	
	350°	450°
0	3 cm	3 cm
2	3 cm	3 cm
4	4 cm	5 cm
6	6 cm	9 cm
8	10 cm	17 cm
10	18 cm	20 cm
20	18 cm	19 cm

A. Based on the information given, code the statements in the following:

F for those that are Facts
I for those that are Interpretations

____ 1. The cake rises higher in 450° than in 350°.

____ 2. The ovens were different sizes.

____ 3. At 4 minutes the cake in the 350° had risen less than the cake in 450°.

____ 4. Both cakes were chocolate.

____ 5. Both cakes had eggs in them.

____ 6. At 10 minutes, both cakes had reached their greatest height.

_____ 7. The cakes were baked in ceramic pans coated with Teflon.

_____ 8. The oven door was not opened during the experiment.

_____ 9. The cakes rose at about the same rate.

B. Construct a systematic analysis of the experiment.

Event	Objects in the System
When heat is added to cake batter, it will increase in height.	1. 2. 3. 4. 5.

On page 6 you will find acceptable responses.

Task Activities

In your materials, you will find several objects. If you were to put water in the can and then heat it with the candle, in what way do you think the system would be different?

Suppose you said that the temperature of the water would go up. List three reasons that might affect the temperature of water rising.

1.
2.
3.

Which of these statements are factual observations and which are interpretations?

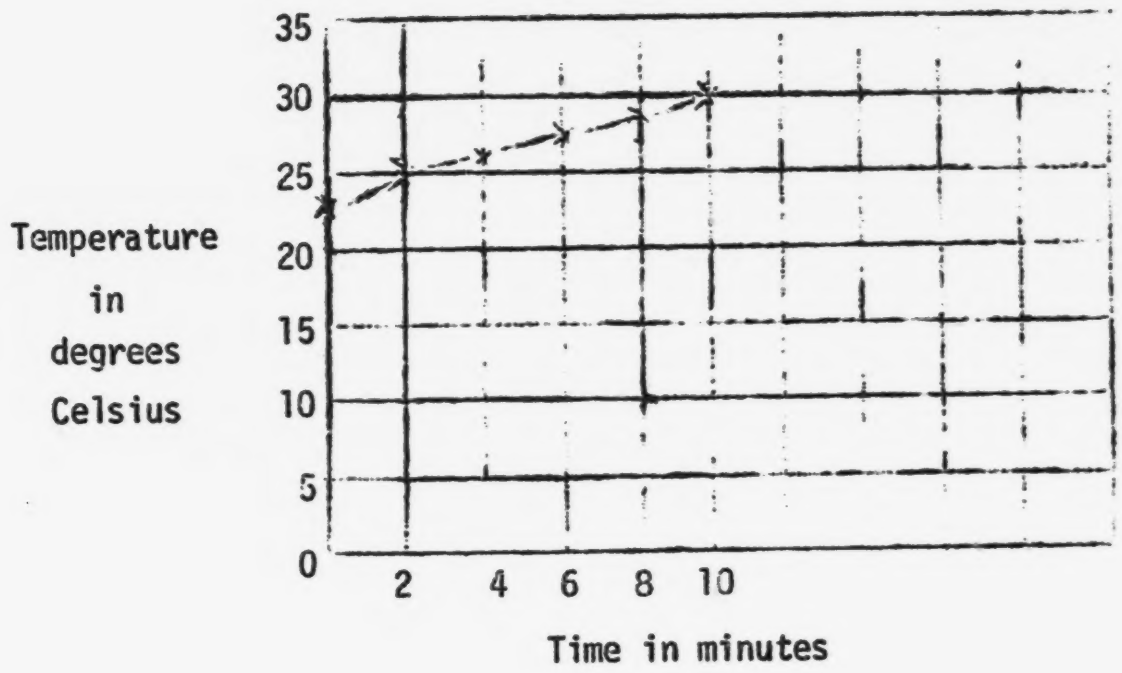
Put 50 ml of water in the can. Now light the candle and place the can on the stand above the candle. Record the temperature for 10 minutes at two minute intervals. Make a graph of your results.

Attached are two graphs of four other groups who have also done this experiment..

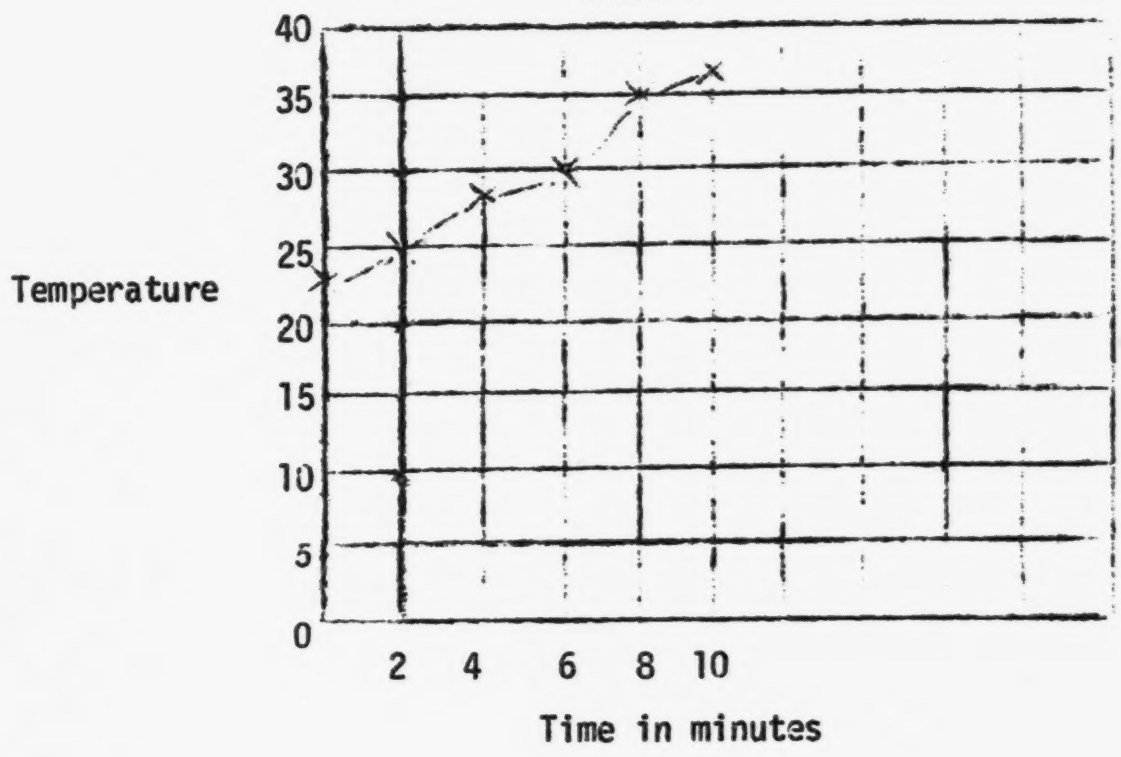
In what way is your graph similar to these?

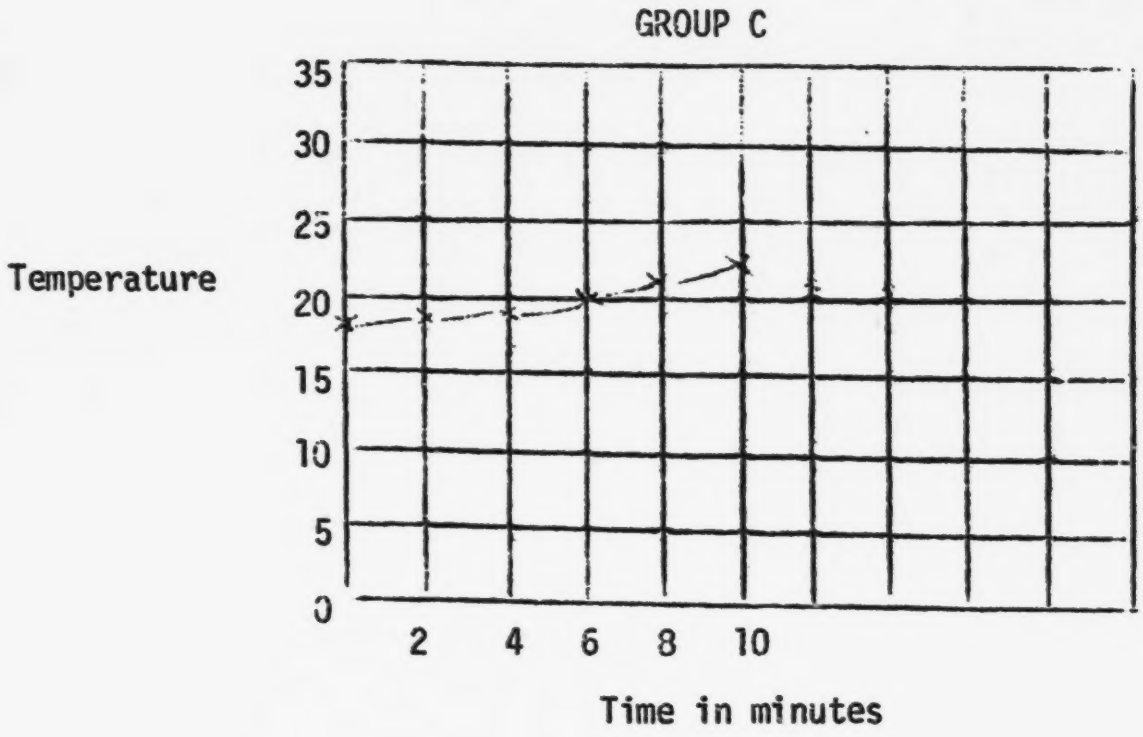
In what way is your graph different from these?

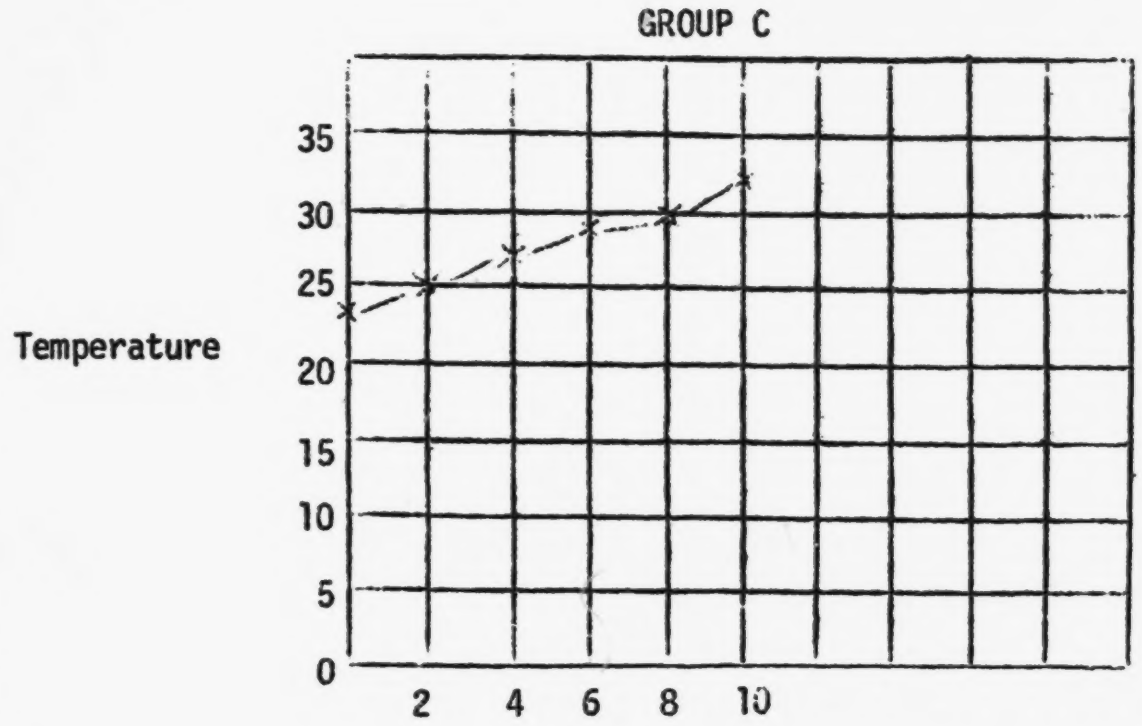
GROUP A



GROUP B




GROUP C
Temperature
35
30
25
20
15
10
5
0
2
4
6
8
10
Time in minutes


GROUP C
Temperature
35
30
25
20
15
10
5
0
2
4
6
8
10

What was the initial temperature for your graph? _____
Group A? _____
Group B? _____
Group C? _____
Group D? _____

What was the final temperature on your graph? _____
Group A? _____
Group B? _____
Group C? _____
Group D? _____

What was the total change in temperature on your graph? _____
Group A? _____
Group B? _____
Group C? _____
Group D? _____

What was the rate of change for temperature for your graph? _____
Group A? _____
Group B? _____
Group C? _____
Group D? _____

List five reasons for the differences in the graphs.

1.

2.

3.

4.

5.

These are reasons for differences in what event?

Describe the event	Now list the objects in your system.
	1. 2. 3. 4. 5. 6. 7.

Look back at your first reason. What object(s) in the system do you think is most closely related to the event for that reason?

Look back at the data for Groups A, B, C, and D. In which group was the change the least?_____ the most?_____

Order the groups from the least to the most change.

Now make a graph of this new organization of the data. Use page 7.

Suppose you know that the amount of water in B is 50 ml.
D is 100 ml.
A is 150 ml.
C is 200 ml.

Relabel the X axis of your graph in volume.

Predict the change in 10 minutes for 275 mls. of water.

Predict the change in 10 minutes for 600 mls. of water.

You are now ready for the Competency Appraisal. Please have the instructor score it as soon as you finish.

Discussion of Task Focus

A. Your answer should be
1. F
2. I
3. F
4. I
5. I
6. F (as far as the data shows)
7. I
8. I
9. F (If you graph the results, you will see that the cake rose twice as much each two minutes as it did in the previous two minutes.)

B. Your objects should include

1. type of cake (or specific ingredients)
2. type of pan
3. type of oven
4. maybe even include the person doing the experiment.

COMPETENCY APPRAISAL

This chart describes the result of putting 50 seeds in incubators at 20°C and 30°C.

Time after putting seeds in incubator.	Total number of seeds that had germinated up to a certain time.	
Hours	20° C Incubator	30°C Incubator
0	0	0
3	0	0
6	0	1
9	1	10
12	5	39
15	23	47
18	36	48
21	41	48
24	44	48
27	47	48
30	47	48

TASK I:

Based on the information given, code the statements in the following lists with

F for those that are Facts.
I for those that are Interpretations.

____ 1. More seeds germinate in the 30°C incubator than in the 20°C incubator.

____ 2. The incubators were the same size.

____ 3. At 6 hours germination was observable in the 30°C incubator.

____ 4. The number of seeds in the incubators were the same.

____ 5. All seeds in the incubator had the potential for germination.

____ 6. At 15 hours nearly twice as many seeds had germinated in the 30°C incubator.

____ 7. Lima bean seeds were used for this experiment.

_____ 8. Water was added every 4th hour to a container inside the incubators.

_____ 9. At 27 hours the seeds in both incubators had germinated about the same.

TASK II:

Construct a system analysis of the experiment.

Event	Objects in the System
Heat affects the germination of seeds.	1. 2. 3. 4. 5.

Now for your first question, which object in the system will you change? _____

Which objects will you keep the same?

_____

_____

How do you think the change will affect the event?

_____

_____

What will you measure? _____

_____

How will you record your results? _____

_____

Repeat this plan for your second question.

What objects to change? _____

_____

What objects to keep the same? _____

_____

How will the event be different? _____

_____

What will be measured? _____

_____

How will it be recorded? _____

_____

Now plan an experiment for your third question.

In your investigation, list those parts of it which will require you to

1. Observe

2. Describe your observations by using space/time relationships

   by Classifying

   by Graphing

3. Comparing your observations through measurement

4. Describing an event

5. Reasoning about your observations

   by Inferring

   by Predicting

6. Constructing an operational definition

7. Identifying and controlling variables

8. Interpreting data

9. Formulating hypotheses

What is the role of these skills in using information in the teaching and learning of science in the elementary school?

You may wish to read more on the philosophy of teaching science in the Commentary for Teachers on pages 1-7 and 157-211.

You are now ready for the Competency Appraisal. Please have the instructor score this as soon as you finish.

Discussion of Task Focus

Your questions should include one of the objects in the system and ask how that object affects the event.

Your design should include changing that specific object in at least three ways and keeping all the other objects in the system the same, and then measuring the event to see if changing the object will result in a changed event.

COMPETENCY APPRAISAL

Describe one question which your analysis of the seeds and incubators experiment in the Competency Appraisal of Task # 17 suggests that you can investigate further.

_____

_____

_____

What would you do to find your answer to that question?

_____

_____

_____

EXPERIMENT COMPLETED--SO WHAT?

Task Objective

At the end of this task you should be able to

> State a question which can serve as a basis for further investigation and to describe a plan for investigating that question.

Task Focus

Refer back to your analysis of the cake experiment in Task # 17.

Describe one question your analysis suggests that you could investigate further.

What would you do to find out the answer to that question?

See page 4 for Discussion of Task Focus.

Task Activities

After a scientist finds out new information about a system, what does he then do?

Look back at your analysis of the system of the candle and water. Based on the new data you have on the relationship of volume of water to temperature change, write three new questions for investigation.

1.

2.

3.